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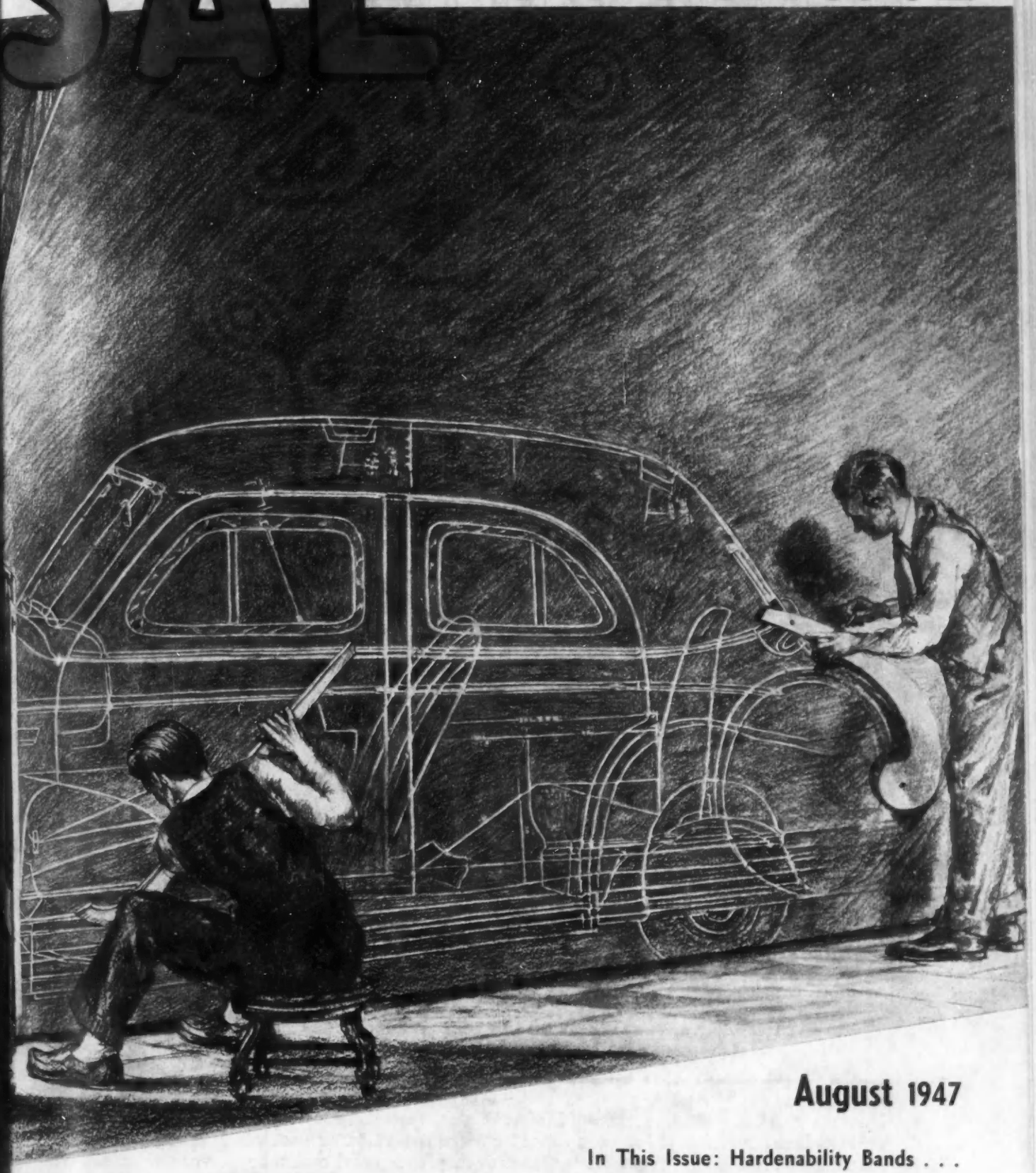

August 1947

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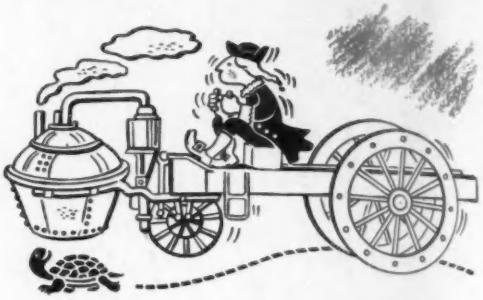
Rumor Page

IT'S RUMORED THAT

today's cars are the heaviest ever built!

Not entirely true. In 1770, a French inventor, Cugnot, built what is believed to be the world's first automobile. It was steam-driven, had front wheel drive—on its one front wheel—and was capable of speeds up to two and one half miles an hour. It weighed about ten tons!



IT'S RUMORED THAT

there'll soon be "Slot Machine Service Stations" in remote spots all over the nation!

With what they're doing with hot hamburgers, machines that make change, and the like, we wouldn't say it *couldn't* be true. But it's really going to ruin things for the poor fellow who tries to pull the old one about "Gosh, Sweetie, I just ran out of gas!"

Contributed by Howard Hodges, Monterey, Cal.

IT'S RUMORED THAT

Perfect Circle was first to produce commercially an alloyed piston ring free from free ferrite!

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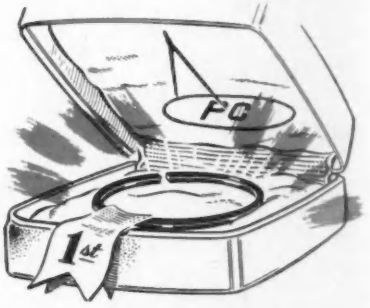

IT'S RUMORED THAT

reloading 3 times saves money for coast-to-coast truck freight shippers!

A true story! Varying state laws allow the use of longer and bigger trailers in the West, and more than one to a tractor. The saving in the use of the larger equipment justifies the cost of the reloading, and actually saves money on the haul!

Perfect Circle Corporation, makers of Perfect Circle *Custom Made* Piston Ring Sets, will pay fifty dollars ($50) for each rumor, fact or fiction, accepted for this page. Send your rumor to Rumor Page, Perfect Circle, Hagerstown 9, Indiana. All contributions become our property and cannot be returned or acknowledged.

For the Sake of Argument

By NORMAN G. SHIDLE

Ideas are accepted by the emotions as well as by the mind. Some quick-minded people are slow emotionally – and vice-versa. . . . So, an idea or a program trying to get across to a man or group has to run on this double track road. Monorailing it may wreck it.

The man who is quick emotionally as well as mentally is in particular danger of cockeyed performance. . . . Working with people of equal or better mental equipment, he may figure that his listeners also have equal speed of emotional adjustment . . . of emotional decisiveness.

The ideas he shoots out may go into other minds at a quick tempo – like the pace of a chorus singing Yankee Doodle in march time . . . but the emotional acceptance may be proceeding much more slowly – like the other half of the same chorus singing My Country 'Tis of Thee. . . . The two absorption paces have to get synchronized before harmony prevails in the listener. . . . The two tunes sung simultaneously give a fine, harmonious effect. . . . But the discord is terrible until the synchronization takes place.

A skilled "presenter" will keep his awareness sufficiently objectified to be conscious of what is happening to his listeners. . . . He will realize that others need time for emotional readjustment. . . . He may even slow up his presentation, "overtalk" on points which – mentally – need no amplification, to give time for emotions to catch up. . . . He even may purposely get final decisions delayed until a later date.

The Cover

● Full-scale layout of the body is one of the earlier steps in the long process of bringing out a new automobile model. Scores of sketches are prepared for a conference of top engineers and sales and management executives who select the general outline. The layout is then detailed with hundreds of drawings before the final set of blueprints goes to the die shop.

Two great names make propeller history

- Two great names, American Airlines and Curtiss Propellers, join in introducing new comfort and safety to air travel. American's recent inauguration of DC-6 service between New York and Chicago marked the *first scheduled airline use of reversible propellers.*

- Reverse thrust means *smooth, air-cushioned landing, effective landing on wet or icy runways, backing or maneuvering without ground assistance, reduced brake and tire wear* . . . outstanding results of Curtiss propeller pioneering. The first of American's postwar fleet, the DC-6 will be followed by the Convair 240 and the Boeing 377, both of which will be equipped with Curtiss reversible propellers.

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Never-Flagging Interest . . .

In papers, in meetings, and in technical committee work, the Society continues to keep pace with the radical changes now in process in the character of powerplants for aircraft.

The Manly Memorial Medal symbolizes SAE's steady, never-flagging interest in development of aircraft engines – in the pioneering days of which its past-president, the late Charles Matthews Manly, "had wrought marvels."

Since establishment of the Medal by action of Council in 1928, fourteen outstanding papers have won this high distinction for their authors – engineers distinguished in many phases of aircraft engine development. This year, Cearcy D. Miller will join the group which has been honored for "the best paper relating to theory or practice in the design and construction of, or research on, aeronautic powerplants or their parts or accessories . . . presented at a meeting of the SAE."

Throughout the years, the winning papers have been chosen from a great number of remarkably fine presentations which have made SAE meetings an unfailing source of vital information on this important area of aeronautical engineering.

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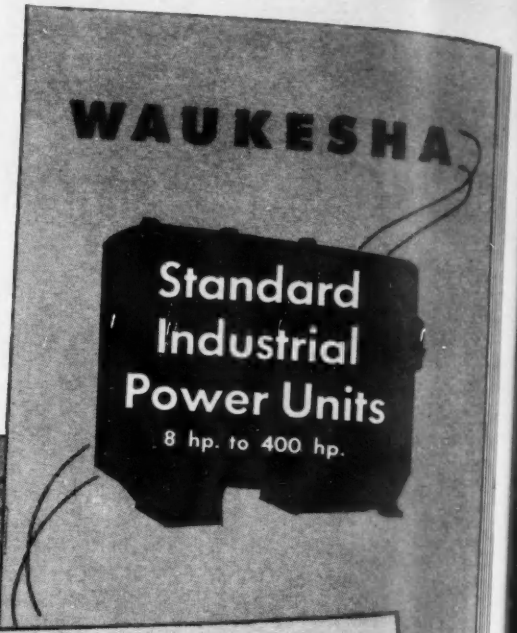

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WORLD'S LARGEST INDEPENDENT AUTOMOTIVE PARTS PLANT

H-BAND METHOD

Tailors Steel To Function Of Part

STEEL bought by the hardenability band specification method offers the engineer – for the first time – the two features he wants in any engineering material. First, the H-band tells him the steel's physical properties – what it can do, instead of what it's made of. Second, it provides him with a basis for determining the most economical steel from which he can produce the part so that it functions properly.

While the engineer is interested in properties of the material such as machinability, ease of manufacturing, and annealing characteristics, his primary concern is whether the material will stand up under the service stresses to be imposed on the part. Once he knows these stresses, he can determine what physical properties the part must possess to resist them. The next job is finding a material that has these properties.

Specifying steel to chemistry is a groping-in-the-dark method of buying because chemical composition tells little about the steel's physical properties. True, steel companies provide physical property charts showing tensile strength, yield point, reduction of area, elongation, and hardness of steels of standard chemistry. But these charts have been prepared largely from data obtained on incompletely hardened test bars, in most cases.

This kind of inexact data, obtained without careful attention to the as-quenched hardness of test bars, led to the misconception that each steel had a combination of physical properties peculiar to itself and different from any other steels.

It has been shown that physical properties of different steels can be closely correlated with hardness and that chemical composition has little bearing on this correlation. Hardness is an index to tensile strength; the relationship is almost linear. Hardness of fully-heat-treated steels in the Brinell hardness range of 200 to 400 accurately depicts tensile properties.

This relationship between hardness and physical

By P. R. Wray

Carnegie-Illinois Steel Corp.
Chairman, Division III, Hardenability Bands of the SAE Iron & Steel Technical Committee

and R. W. Roush

Timken-Detroit Axle Co.
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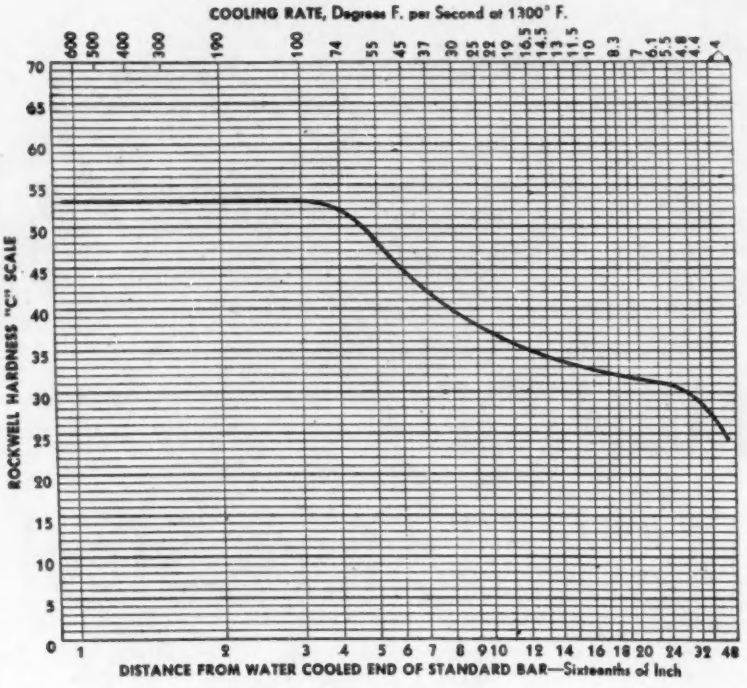


Fig. 1 – Hardenability of SAE 5130. This specimen was heated to 1675F and end-quenched. The Rockwell values along the 1/16-in. intervals along the bar are indicative of the cooling rate

properties led to the development of a method of predicting hardening properties of steel before it is made into a part. This method is the Jominy and Boeghold end-quench test (see pp. 303-316 of the 1947 SAE Handbook) that was adopted by the SAE, American Iron and Steel Institute, and the American Society for Testing Materials.

This test reveals the following five facts about the specimen:

1. Maximum hardness and maximum strength at a cooling rate of about 600 F. per sec., which corresponds to the upper limits of quenching speed encountered in most shops.
2. Depth of hardness;
3. Mass effect;
4. Probable microstructure of the steel under known heat-treatment conditions, and
5. Ordinary mechanical properties.

The SAE and AISI jointly developed tentative hardenability bands for 62 "H"-steels (see pp. 24-85 of the SAE-AISI publication, "Hardenability of Alloy Steels," June, 1947) based on data from many heats. With these bands, the engineer can more quickly select the proper steel for a given part without reference to details of chemical compositions of alloys. He can specify maximum and minimum hardenability limits for a given type of steel, giving him greater control of hardness variations from lot to lot so that retreats are minimized.

Table 1 – Relationship Between Cooling Rate and Jominy Bar Hardness

Location in 2-in. Diam. Bar	Deg. F per sec Cooling Rate, Oil Quenching	Corresponding Locations on J Bar	Hardness, Rockwell C for SAE 5130
Center	18	11/16	36
½ Radius below surface	24	9/16	38
¼ Radius below surface	32	8/16	41
Surface	60	4.5/16	50

Cooling Related to Strength

Let us now see what the H-band tells us. We should know how slowly a steel can be quenched and still obtain maximum strength. Size of a piece determines how fast it may be cooled by quenching and this determines the amount of alloy needed to make the steel harden when cooled at the rate obtainable in the piece.

A typical hardenability curve, shown in Fig. 1, shows the Rockwell hardness at sixteenths of an inch from the quenched end of the specimen. This really shows the relationship between cooling rate and hardness. We could substitute cooling rates along the abscissa for the 1/16-in. intervals. From this curve we can predict the hardness at the surface and at any point between the surface and center of any sized round quenched in either oil or water.

As already stated, the cooling rate required to

harden a certain steel is important because it determines the alloy content and is the means by which steel hardenability is classified. Certain steels can develop strength in light sections, but not in heavy sections.

If, for example, we select steel for a 2-in. round shaft to be oil quenched, we will find from charts prepared by the SAE Hardenability Test Committee that the cooling rate at the center is 18F per sec., or about the same as at 11/16 in. on the Jominy bar. At one-half radius below the surface, the cooling rate is 24F per sec, or at about 9/16 in. on the Jominy bar. At one-quarter radius below the surface the cooling rate is 32F per sec, or at 8/16 in. on the Jominy bar. At the surface the cooling rate is 60F per sec, or at 4.5/16 on the Jominy bar. Hardness at these points on the curve in Fig. 1 will show that a 2-in. round of 5130 steel, quenched in oil at 1675F would have a cross section hardness as given in Table 1.

H-Band Advantages

Steels produced to H-band specifications not only afford the engineer a better index to performance predictability, they are also within much closer limits on hardenability than the same steels manufactured solely to chemical composition.

Examination of many data shows that H-band spreads fall well within hardenability spreads of steels produced to chemistry specifications.

Fig. 2 bears out this point. The solid lines show the H-band for SAE 8630 steel and the dotted lines represent the hardenability range of 126 heats of the same steel purchased to conventional chemical composition. Obviously the user gets a steel varying over narrower ranges of hardenability when he specifies by the H-band method.

This permits the buyer to standardize more readily on heat treating processes and equipment. It cuts down the number of hardening and tempering treatments required to obtain the desired uniform characteristics in the finished part.

Using H-band steels extends appreciable labor and materials savings by reducing reprocessing and rejections. And it will practically eliminate those peculiar heats that fall within chemical specifications, but do not anneal, machine, or heat-treat satisfactorily.

Chemistry of H-Band Steels

But to maintain these close hardenability limits, the steel maker must be given more latitude than in conventional chemical ranges. This is necessary to allow him to make adjustments in his melting practice and to take full advantage of any elements that are high or low. Giving him several points leeway in the chemical limits for each alloy in the steel allows him to deliver a steel more closely controlled than under the chemical composition method of buying.

This added flexibility together with modern methods of control permit the steel mill to balance the alloy before the heat reached ingot form. Restricting the steel mill to conventional chemical composition would nullify the advantage of closer hardenability spread in H-band steels.

If, in making a heat of 8620 "H" steel, for example, preliminary chemical analysis shows nickel and molybdenum are toward the high side of the permissible range, less manganese or chromium, or both can be added to bring the steel within hardenability specifications. This flexibility of wider chemistry range will likewise permit heats having low nickel and molybdenum to be balanced to the correct hardenability by working to higher manganese or chromium limits.

Apparently both the steel producers and the user stand to gain from the H-band method of specifying steel. The user can order steel to end result because hardenability gives him a measure of performance. The steel producer can do a better job in making the kind of steel the buyer wants because he is given the latitude he needs.

Yardstick for Steel Suitability

Equally important to the user is the ability to use H-bands as tools to compare different steels. Since any given part can be produced from more than one steel, the engineer wants to find the cheapest steel of those under consideration. A method has been presented which determines the cost per unit of hardenability.

This method involves a theoretical value known as the DI. It's the ideal or largest diameter of a given steel that will be hardened throughout under ideal quenching conditions. Comparing the ratio of cost per lb to DI of one steel with that of an-

SAE Iron & Steel Technical Committee members Wray and Roush present here a consensus of Committee opinion on why the H-band method of specifying steel benefits the user.

They illustrate how hardenability gives the engineer a much closer approximation of the steel's strength than does chemical composition alone. H-bands, they say, offer the user a means of finding the steel best suited to the part, both from a functional and a cost standpoint.

A complete guide to the H-band method of specifying steel has recently been published in the SAE-AISI booklet "Hardenability of Alloy Steels." (See article "New Publication Guide to H-Band Steel Use," on p. 73.)

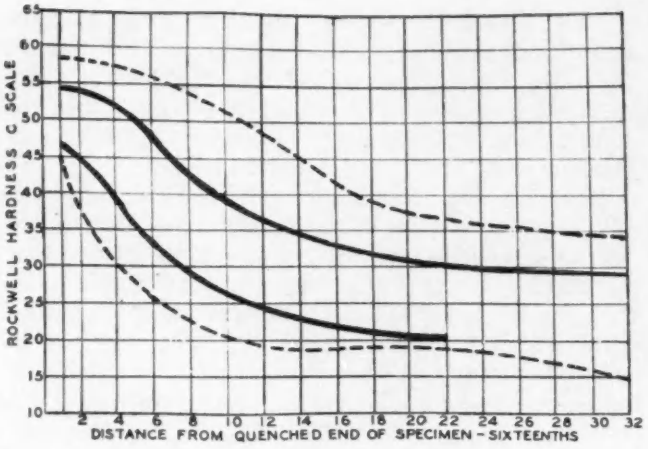


Fig. 2 – Average hardenability spread for all published H-bands is 26% closer than hardenability spreads of steels produced to chemistry specifications. Shown here is that the tentative H-band for SAE 8630 steel (solid lines) falls within the hardenability spread resulting from chemistry specifications

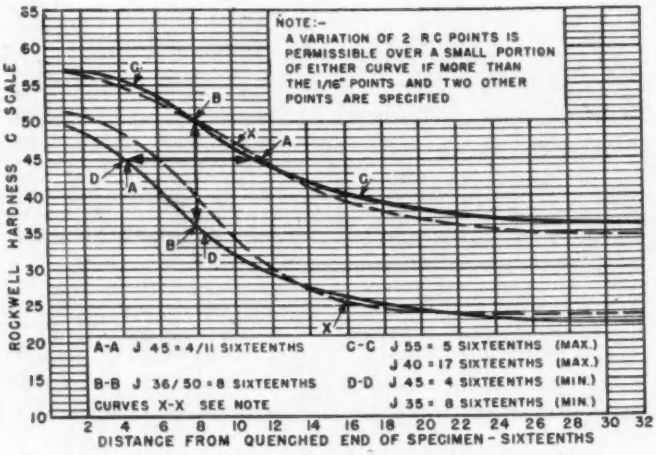

NOTE:-
A VARIATION OF 2 R C POINTS IS PERMISSIBLE OVER A SMALL PORTION OF EITHER CURVE IF MORE THAN THE 1/16" POINTS AND TWO OTHER POINTS ARE SPECIFIED
A-A J 45 = 4/11 SIXTEENTHS
B-B J 36/50 = 8 SIXTEENTHS
CURVES X-X SEE NOTE
C-C J 55 = 5 SIXTEENTHS (MAX.)
J 40 = 17 SIXTEENTHS (MAX.)
D-D J 45 = 4 SIXTEENTHS (MIN.)
J 35 = 8 SIXTEENTHS (MIN.)
ROCKWELL HARDNESS C SCALE
DISTANCE FROM QUENCHED END OF SPECIMEN - SIXTEENTHS

Fig. 3 – This illustrates the several methods of specifying requirements for H-band steels

other of equal hardenability will disclose the more economical one.

A case in point is the comparison of 4615 and 1320 steels for light car gears. Both grades have the same DI values, but the nickel-molybdenum types are more than twice as costly as the 1300 manganese series. Although carburizing characteristics of the two steels differ, it is felt that carburizing is secondary to hardenability in this case. Therefore, this job does not justify the more costly 4615 steel.

When ordering standard "H" band steels, it is recommended that two points be specified in any one of the following ways to designate desired hardenability.

1. The minimum and maximum hardness values at any desired distance. (This method, shown by points B-B in Fig. 3, would be specified for the curve as J36/50 = 8 sixteenths. Obviously the distances selected would be that distance on the end-quench bar that corresponds to the section used by the consumer.)

2. The minimum and maximum distances at which desired hardness value occurs. (This method, shown in Fig. 3. as points A-A, would be specified for the curves as J45 = 4/11 sixteenths.)

3. Two maximum hardness values at two desired distances, shown in Fig. 3 as points C-C.

4. Two minimum hardness values at two desired distances, shown as points D-D in Fig. 3.

5. Any point on the minimum hardenability curve plus any point on the maximum curve.

Where necessary, the maximum and minimum limits at the 1/16-in. point may be specified in addition to two other points.

Where more than two points on the hardenability band (other than the maximum and minimum limits at the 1/16-in. point) must be specified, a tolerance of two points Rockwell C over any small portion of either curve is permissible, as shown by the X-X curves in Fig. 3.

H-Band as Design Tool

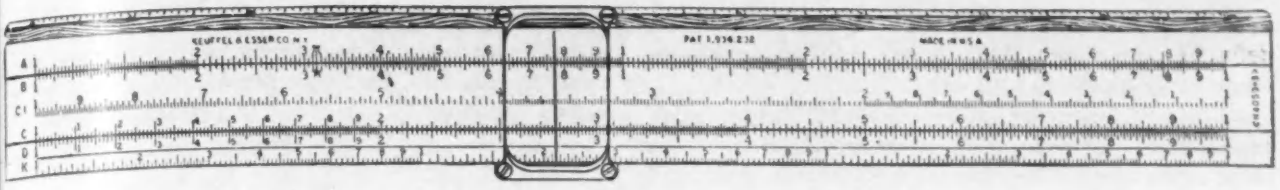
The engineer using H-bands rather than conventional chemical limits examines each steel part made in his shop. He must compare hardness of critical areas of the part with hardness shown on the end-quench curve for the same steel, such as the one shown in Fig. 1.

But this chore is not as complex as it first appears. (A. L. Boegehold detailed a method that applies to any part of his paper, "Selection of Automotive Steel on the Basis of Hardenability," SAE-AISI publication "Hardenability of Alloy Steels," June 1947, pp. 87-128, and SAE Transactions, vol. 52, No. 10, pp. 472-485.)

Steel maker and user metallurgists are convinced of the merits of H-band steels. They have gone a long way toward giving the engineer all the tools he needs to apply the method and materials in practice. He has readily available to him the specifications, method of finding the most economical and best-suited material for the product, and a convenient way of ordering that material. Exploiting H-band steels is the engineer's job.

Engineering Philosophy Satisfied

The rewards to be reaped by ordering steel to hardenability bands are many. At long last the engineer has within his grasp a performance specification that will help him select the best steel for the job by satisfying the engineering needs and economics of manufacturing. The path is now clear to achieving the practical engineer's criterion of "what's good enough is best."



THE ENGINEERING PROCESS

EXCERPTS FROM A PAPER* BY

MERRILL C. HORINE

Mack International Motor Truck Corp.

ENGINEERING is the application of science to the design, development, and construction of useful structures and articles. Automotive engineering is concerned principally with special phases of mechanical, chemical, electric, hydraulic, and metallurgical engineering.

The end product of automotive engineering is a design which can be built to produce useful vehicles which can be operated economically.

Purpose

Out of good engineering comes most of the worth of any product. For no matter how carefully it may be built, how energetically it may be sold, or how skillfully it may be operated and maintained, a product can produce maximum benefits for both its user and producer only when its original design embodies those characteristics which enable its parts to work efficiently for the longest practicable time, with the least maintenance, permit ease of operation – and all this at the lowest cost.

It is good engineering, because it is good economics, to have a design which will make the product profitable to the buyer. The product must also be economical to manufacture to keep its original cost low.

Conflicts

To gain these ends, the engineer is continually confronted with conflicting effects. If the engineer designs solely for the ultimate in performance, the vehicle will probably be prohibitive in cost of manufacture and operation. On the other hand, too much emphasis on low cost is likely to increase operating cost and reduce salability.

To achieve the lowest manufacturing cost possible the engineer may sacrifice so much of other desirable features that the cheaper product will prove to be the most expensive.

Disproportionate attention to ease of operation may result in such complication that maintenance will be excessively tedious and costly because of the multiplicity of automatic gadgets and compensating devices designed to make things easier for the operator.

Conversely, if the vehicle is designed with all other considerations subordinated to simplicity of maintenance by providing extreme accessibility, resistance to wear, and imperviousness to corrosion and other destructive forces, it will cost too much, will be overweight, and too large. It may be difficult to operate, and might well be wholly lacking in aesthetic appeal.

Too much emphasis upon styling of today's automobiles shows aberrations of design which seriously interfere with utility. Just try to put tire chains on a 1947 car, or try to drain its radiator!

Compromise

This is what "engineering is compromise" means. The optimum, or compromise between conflicting effects, will produce the best results. This achievement is the engineer's chief responsibility.

A genius has been defined as a man with an in-

* Paper "The Engineering Process," was presented before the SAE Student Branch of the College of the City of New York on March 20, 1947.

finite capacity for hard work. Perhaps a better definition is a man who has a highly developed sense of proportion.

Ability to exercise unusually good judgment in engineering depends upon a combination of these three qualifications: Knowledge, experience, and judgment. These are equally important legs of a tripod.

Education and Experience

Theorists, long on knowledge, but shy of experience, cannot exercise sound judgment, no matter how clever they may be. Similarly, an engineer of wide experience but lacking essential knowledge rarely accomplishes outstanding results.

Knowledge is not necessarily schooling. Some brilliant engineering geniuses never attended college, and some of the most tragic failures have been made by men of high educational qualifications.

A sound engineering education is of tremendous advantage because education is simply an efficient means of obtaining knowledge.

An engineer's education should never cease when he receives his degree. That is often the real starting point – truly his commencement. The successful engineer ceaselessly follows developments on a broad scale, and not only in his specialized field of engineering. The best way to do this is through membership in the Society of Automotive Engineers, the ASME, AIEE, ASTM, and other engineering societies.

Even this is not enough. In an extremely able paper,[1] J. M. Zeder pointed out the necessity of engineers keeping posted on the complementary activities of the companies for which they work.

Engineering is only one of the essential activities of a successful company. Young engineers often make the mistake of assuming an attitude of professional superiority over accountants, salesmen, purchasing agents, and tool designers. This is as shortsighted as it would be for a powerplant to belittle the transmission, axle, and brakes.

Judgment

Above all else, good judgment is important in engineering – not because this leg of the tripod is more important than the other two, but because so few men possess enough of it.

Laymen visualize the engineering process as the result of inspiration, but it is usually the result of perspiration. Successful design is not the work of a single genius. Today it is as impossible for a single engineer to produce a commercially successful design as it would be for a musician to play a symphony alone.

[1] "More Power to Engineering" by J. C. Zeder, chairman of the Engineering Board, Chrysler Corp., SAE Journal, November, 1945, p. 17.

At the head of a successful engineering staff is a leader capable of coordinating the work of the many specialists, just as a symphony orchestra requires a conductor of great interpretative ability.

Engineering Objectives

In setting out to design a component or a complete vehicle, the engineer has several main objectives. The product must do: (a) A better job at no higher cost, (b) An equal job more economically, or (c) A better job more economically.

Therefore, the design must:

Perform better than that which it is to replace, or at least as well;

Possess sales appeal;

Be easy to service;

Be easily adapted to production methods and equipment economically available;

Be made of materials economical to use, and

Avoid patent conflicts.

Research

Rarely are such results achieved by direct design. Diligent effort is required in consecutive order. First, there must be research to determine the probable market for the product. Next, study must be made of other efforts in the field. Then basic scientific laws must be studied to determine limitations, if any. And possibilities of a departure from conventional practice must be explored.

Research is the process of scientific exploration and interpretation applied to a specific commercial project, and is thus the connecting link between pure science and engineering.

Years ago the problem of preventing axle shafts from breaking in the differential splines was beyond the then existing engineering formulas and experiences. A research project brought about two major developments: Graduated heat treatment, and development of the involute spline. Fundamentals were then established which have been useful ever since in the design of many mechanisms.

Invention

Second, there must be invention. A designer who only changes a fit or the disposition of metal in a part actually invents a change which he hopes will be an improvement. Not all inventions result in patents.

The day of the independent inventor is about over. So much is now known about the fundamentals of physics, mechanics, and other sciences, that today the inventor's chief role is perceiving the need for some "new and useful improvement."

Engineers do invent by contriving combinations of known mechanical movements, structural forms, or physical properties by which some need is met.

Calculation

Engineering could not go far without mathematics. Design of a simple gear requires tens of thousands of calculations, covering forces, stress distribution, moments, moduli, deflections, expansion and contraction, angles, areas, and analysis of motion.

Many mechanical actions and relationships cannot be predicted by pure reason nor analyzed visually. These can be studied only by mathematical analysis.

For example, nobody can invent a gear tooth contour. Many thousands of intricate calculations are required to design the gear.

Design

Fourth, there must be design. Ranging from the blacksmith's fit and try to the complete detailing of all parts of an intricate machine, design covers a wide area.

This is the blueprint stage of a new product, but the tracings from which the prints are made are accurate dimensional representations of the form and relationships of parts.

A simple rear axle requires hundreds of such drawings, all done with meticulous care so there will be perfect fit in assembly when the pieces have been manufactured.

Experiment

Unlike the law and religion, all is not cut and dried in engineering. There must be experiment because natural laws are discovered, and not enacted.

There is yet far more to be learned than has been discovered through the slow centuries of the past.

Experiment checks the theories and postulates of engineers, and experimental laboratories of engineering departments of many companies are extremely large, and are equipped at great outlay of capital.

Simplification

Modification and correction of original design is required to simplify the product, to adapt it to ease of production and often to make the product more serviceable.

Here is the basis for most of the deserved criticism of engineers. In the infancy of any industry, the engineer was simply asked to make the contraption work.

As the industry grows, competition forces each company to produce at lower and lower costs, and to improve quality by design or different materials, or both.

On the success or failure of the engineers to do this often depends whether a company stays in business or goes bankrupt.

Thus the engineer must know a great deal about manufacturing processes, the economics of production, availability and the machinability of materials, and different methods of fabrication.

Responsibility Of Designers

The designer's responsibility is great, because he commits the company's production department to large expenditures for tools, machinery, and materials when a design has been released. Likewise he commits the sales department, the merit of which largely determines the success of a company.

Upon the soundness and customer satisfaction of its product depends the financial success of the whole enterprise.

These objectives, methods, and responsibilities of engineers demand the best any man can offer. But in turn, they offer the utmost in challenge to his abilities, and a genuine satisfaction in accomplishment.

If engineering in general is often disappointing in pecuniary rewards, the fault is most likely to be found in the engineers themselves than in the limitations of management.

Because whatever his calling, man is always limited by how well he can work with harmony and understanding with other men.

Most engineers are notoriously poor salesmen, but leaders in engineering are almost always gifted with the ability to influence other people favorably. They have learned that their own engineering accomplishments are strictly limited by the degree to which they have been able to get their ideas accepted by other men who must finance their development, manufacture, and sale.

Most engineers are flagrantly inarticulate. Reticent, sensitive and retiring, many good engineers fail because they are unable to make themselves understood when they speak or write.

Clear expression is as important to an engineer as to a lawyer, a journalist, or a diplomat. Clear expression is but the reflection of clear understanding of the subject by the engineer writing the report.

Except for college textbooks there is probably no more abominable class of English literature extant than engineering reports. They are calculated to make the reading as uninteresting, and the facts as inaccessible as possible, while violating every known rule of psychology, good writing, and eye appeal.

Most of such reports would be improved incalculably if simply reversed end for end, as Zeder suggests.

Never before has the profession of engineering offered greater opportunity for service for civilization, for an interesting and an active career, and for rewards for honest, intelligent effort than it does today.

Every technological advance since the dawn of the industrial age has broadened and intensified the need for more and yet more engineering.

This is particularly true of the automotive industry.

Research Uncovers Diesel Fa

BASED ON A PAPER* BY **W. F. JOACHIM** U. S. Naval Engineering Experiment Station

(This paper will be published in full in SAE Quarterly Transactions)

NAVAL wartime research tried to determine all operational characteristics and to uncover design and structural defects in more than 70 types of diesel engines. Results aimed for were reliability of improved designs and new parts and determination of wear rates to set up replacement schedules.

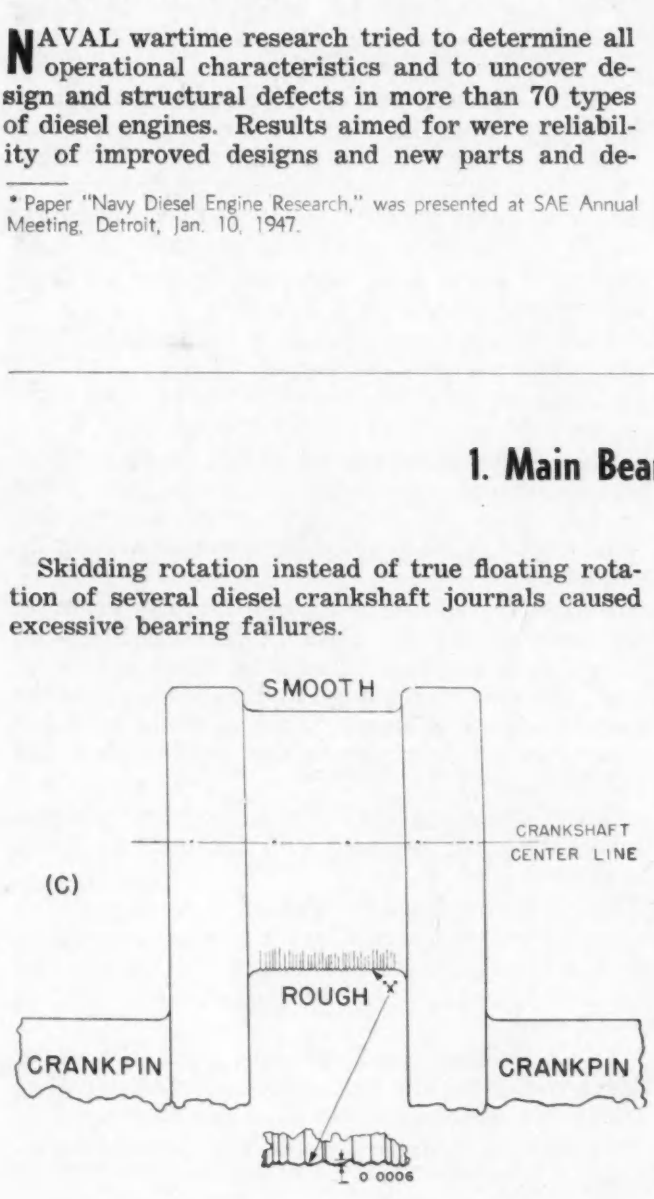
The program was extensive. It encompassed projects such as life tests, torsional vibration tests, performance and rating tests, exhaust muffler tests, and cold starting tests.

Discussed in this article are four unusual types of failures encountered in these investigations and the remedies prescribed.

* Paper "Navy Diesel Engine Research," was presented at SAE Annual Meeting, Detroit, Jan. 10, 1947.

1. Main Bearing Failures

Skidding rotation instead of true floating rotation of several diesel crankshaft journals caused excessive bearing failures.



Most severe skidding comes from uncounterbalanced shafts – where both sets of cranks, pins, and connecting-rod jig ends on either side of the journal act in the same direction. They skid the journal around the bearing on its centrifugally-loaded side. Piston and rod reciprocating forces enlarge these skidding loads, except at top center on a combustion stroke.

Journal skidding disrupts dynamic oil films and drastically reduces safe bearing loads. Effects of excessive skidding loads on a large center main crankshaft journal are shown at left. Heavy skidding scuffed and lined the centrifugally-loaded side; the unloaded side remained in excellent condition. After reaching the degree of roughness shown, it was impossible either to retain the old bearing in service or even to run-in a new one.

While high-capacity bearing materials and designs can extend bearing life under these conditions, properly counterbalancing the crankshaft in the original engine design is the more positive approach.

Failure Causes and Cures

2. Cylinder-Head Failures

Many diesel cylinder-head failures took the form of unusual distortions, cracking, and burning, loosening, and pounding-in of valve seats.

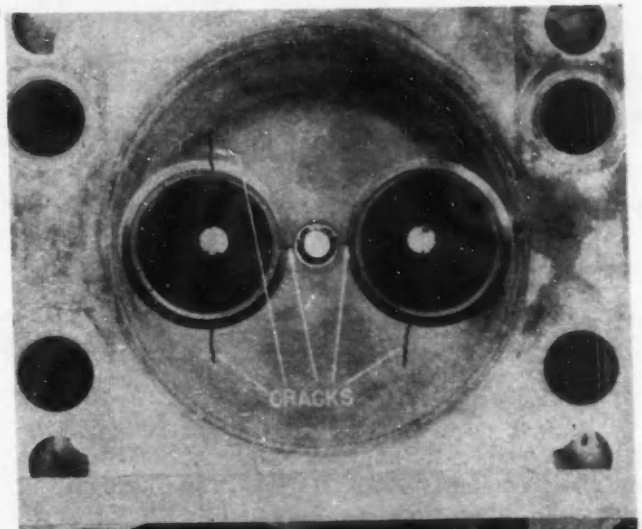
It all stems from improper cooling . . . directing cooling water flow from the cylinder-head lower deck to the upper deck between cylinder manifold sets instead of over combustion chamber hot spots . . . concentrating on where little cooling is needed instead of where maximum cooling is required.

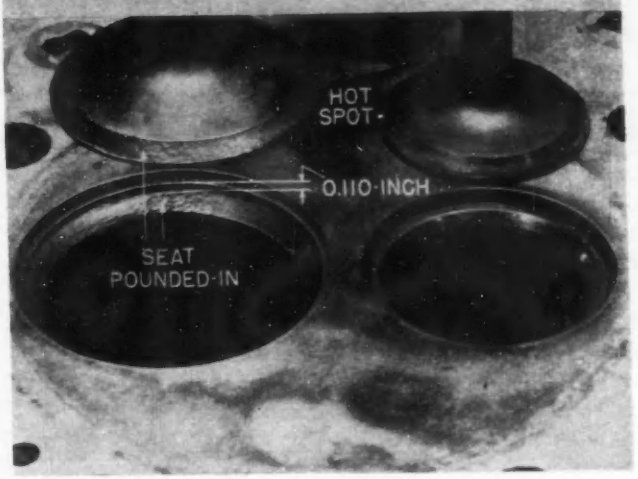
In one case, a 0.015-in. upward distortion of a 6-cyl head – caused by two inadequately cooled spots at each cylinder – took compression sets during engine operation; but at room temperature, these spots were in tension and bowed the head longitudinally. Such distortions bring on cylinder-head stud and gasket failures.

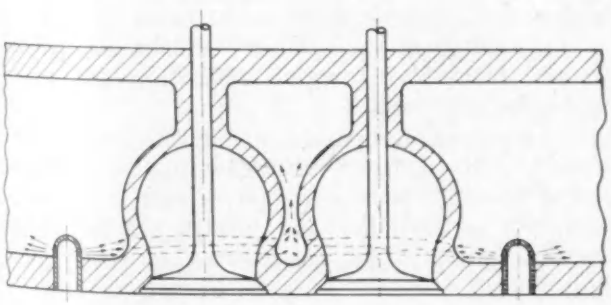
The photographs at right show cracks and badly pounded-in valve seats caused by hot-spot expansion and valve-seat distortion.

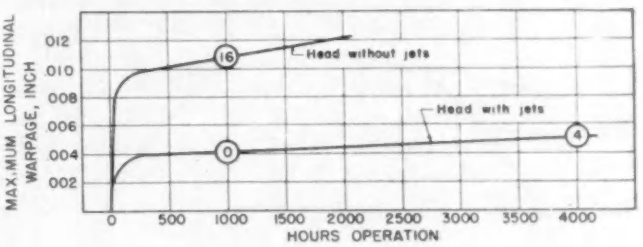
Jetting cooling water through a drawn-brass jet nozzle over the hot spots (as shown below) increased the life of these same heads several hundred per cent. The curves below bear this out. (Figures in circles represent average number of cracks per head.)

This and similar experience shows that analyses of cylinder-head heat flow and directing cooling water over hot spots will pay big dividends in engine operation, reliability, and life.









3. Connecting-Rod Bearing Failures

Faultily manufactured bearings occasionally cause unusual failures.

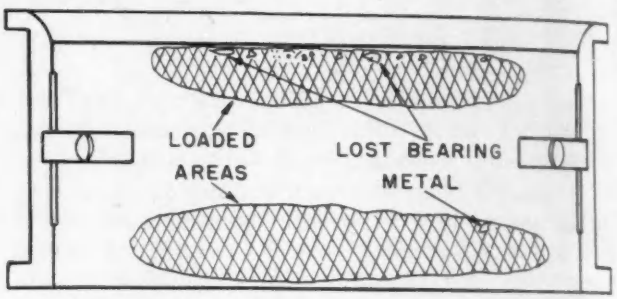
One shipment of submarine-engine connecting-rod bearings was tested to find why they failed. Preliminary measurements showed the bearings to be concave; overall bearing shell thickness ranged from 0.0008 to 0.0013 in. thinner at the center than at the ends. Diametrical measurements of the bearings in the connecting rods confirmed this fact.

The bearing surfaces were barrel-shaped when assembled, probably due to a fault in the jigs used in final boring of the bearing linings.

Four of these bearings (two of which had failed after only 234 hr) were tested as received in the submarine engine. Fatigue cracks, loss of bearing metal, and some scuffing of the linings – shown in the drawing – occurred at the high ends of the upper shells due to excessive loading.

Hand scraping concave surfaces of similar bearings in the shipment to a cylindrical shape further proved this to be the cause of failure. Service life of the scraped bearings was increased many times – ranging from 3500 to over 8500 hr.

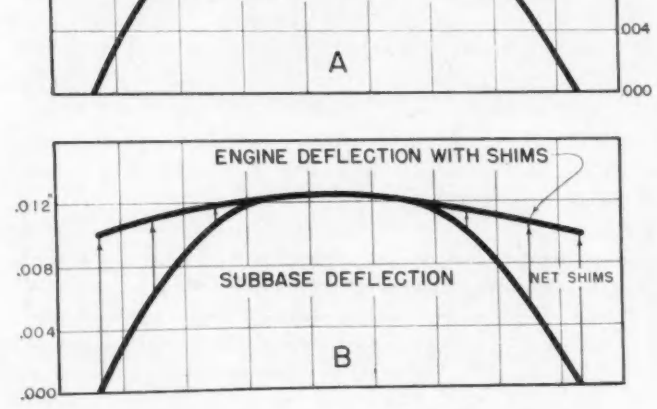
Only careful inspection of bearings after final machining, and again before and after installation in the connecting rods, will prevent failures of this type. Inspectors should examine bearings for defects such as porosity and cracks, for conformance with dimensional and crush specifications, parallelism of surfaces, and proper chamfering of oil-groove edges.



4. Crankcase Distortion

Two large submarine diesels were found to be chronic breakers of engine hold-down bolts. Checking all alignments, bolt installation techniques, and even switching to stress-relieved bolts failed to disclose the cause.

Since all alignments were correct, suspicion was cast on vertically-upward thermal distortion of the engine frames at the ends under operating temperatures.



Typical distortion in chart A, at left, shows the unbolted engine frame bowing 0.008 in. upward at the ends at standard operating temperatures under full engine horsepower. Under these conditions, the subbase distorted 0.012 in. vertically at the center.

The subbase – rigidly bolted to a 6-in. bed plate that was bolted to a heavy reinforced-concrete foundation – forced the bolted engine frame to conform to its own distortion. Pulling the "hot" engine down a measured 0.018 in. at the ends plus normal engine vibration caused fatigue failure of the end hold-down bolts and cracked the engine frame.

Chart B shows the shim thicknesses between the engine and subbase that bowed the engine 0.010 in. *downwards* at the ends at installation, but decreased total "hot" engine distortion and eliminated the fractures.

Since normal temperature distributions tend to distort most subbases vertically, engine manufacturers should insure as nearly equal frame temperatures as possible and provide ample fillets, rounded frame edges, and more equal stress distributions.

AIRBORNE RADAR . . .

How It Works, What It Does

BASED ON A PAPER* BY

Frank C. White

American Airlines, Inc. Supervisor, ANTC Electronics

FROM the fairyland of microwave techniques has been developed airborne radar that will lead to safer air travel. While little is yet known about these devices, American Airlines' test and modification program with APS-10 airborne radar showed that this easy-to-use unit can give the pilot the vision he needs for flying and even landing approaches in bad weather.

How It Operates

The APS-10 operates on a wave length of about 3 cm. A magnetron generates radio frequency energy in the form of bursts or pulses with a peak power of about 8 kw. The magnetron, its power source, and modulator (switching device) are located in a pressurized cylinder together with the radar receiver.

A 1½-in. ID copper-tube wave guide – held to very close tolerances – feeds the 3-cm power to the antenna. The antenna consists of two small rods, about 0.5 in. long, located in the focus of an 18-in. parabolic reflector. The parabolic reflector focuses the 3-cm energy into a beam about 5 deg wide by 7 deg high.

An azimuth drive-motor rotates the antenna and its parabolic reflector so that the radio frequency sweeps around the aircraft, much like a rotating searchlight beam. The antenna is usually located in the nose or under the belly of an aircraft so that the area ahead and below is scanned or illuminated.

Pulses or bursts of energy strike ground objects and are reflected back to the antenna. Larger objects as well as those that are better reflectors of 3-cm radio frequency energy return a stronger signal to the aircraft antenna.

The cathode ray tube in the unit displays azimuth, distance, size, and reflecting capabilities of ground objects. The APS-10 cathode ray tube has a 5-in. diameter display screen. The PPI (polar plot indication) display employed positions the airplane at the center of the tube.

Distance from the aircraft to an object is measured from the center of the tube radially outward. Azimuth is read directly. The top of the tube is 0 deg, ahead; the bottom of the tube is 180 deg, astern.

Interpretation of the PPI display requires no mental gymnastics. It's just as natural to a pilot as looking out of the cockpit window.

As the antenna rotates, a line of light known as the sweep – which reaches from the center of the PPI tube outward to its edge – rotates in exact synchronization with the antenna. If the antenna points ahead, the sweep on the PPI tube is at 0 deg. The antenna and sweep make one revolution every 2 sec.

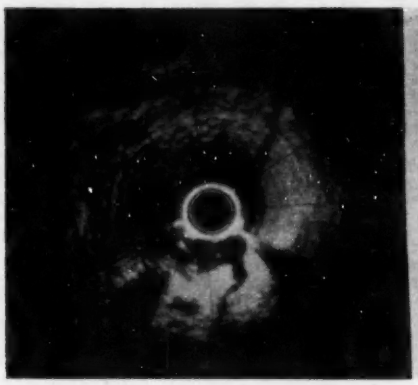
As the sweep rotates, it excites a phosphorescent coating on the PPI screen which glows dimly after the sweep has passed. In darkness the illumination is adequate. In daylight it's necessary to view the PPI tube through a truncated-cone hood which shuts off most direct illumination of the screen from outside sources.

Biggest shortcoming of airborne radar is the poor illumination of the PPI tube.

First tests with APS-10 were anything but encouraging. It did not show buildings and the radar alone did not give complete assurance that mountains or ridges could be avoided. But modifying the radar antenna to produce a pencil beam turned the trick. The pencil beam is an inherently

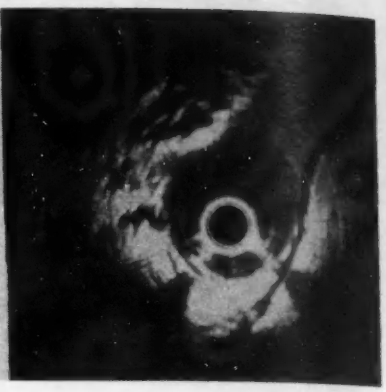
* Paper "American Airlines' Evaluation of Airborne Radar," was presented at SAE Mid-Continent Section, Tulsa, Feb. 7, 1947.

A Radar Flight as th



1. The range switch has been set for the 12-mile range. The plane is flying about 1 mile to the left of a river – the irregular, continuous dark line on the PPI. The mottled effect of the flat terrain is broken up by three large shadow areas ahead and to the left.

2. As we continue our flight by airborne radar, we note on the PPI scope that the largest shadow area – 8 miles ahead and extending to the left – begins to move in toward zero range. The safety circle is already being slightly pushed in on the left (high ground) side.



3. The bright edge of the echo from the near side of the hill is pushing into the safety circle. Shallow echoes appear where the radar looks over the lower foothills of the oncoming ridge. Here the pilot decides whether or not he can climb over the approaching obstruction.

basic and simple method of applying airborne radar to prevention of terrain collision.

Drawings and explanations on pp. 30 and 31 show you how the pencil beam is used. The drawings exaggerate beam width and aircraft height to facilitate interpretation.

There are two questions often asked about airborne radar:

1. Will the pilot be looking at the radar PPI tube often enough to know that terrain collision is imminent? and

2. Isn't it so hard to read the radar PPI display that the pilot will not be able to interpret the conditions leading to possible terrain collision?

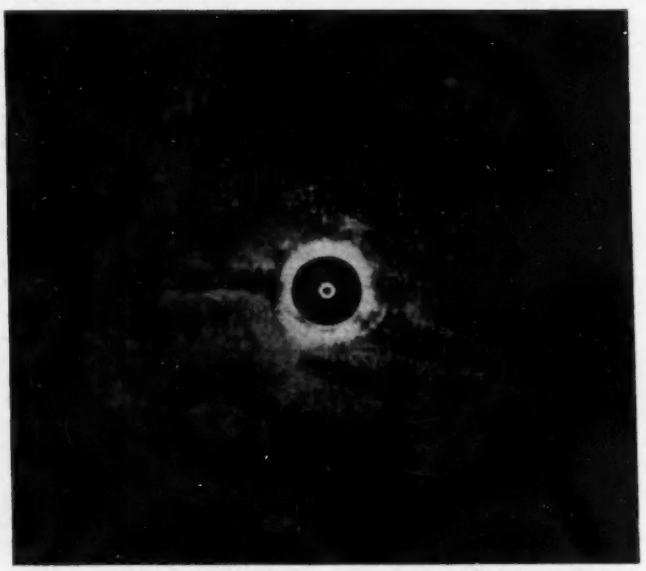


Fig. 1 – Manhattan island looks like this to airborne radar in a plane flying over the Hudson River, west of Manhattan. Central Park – being a flat grassy area amid tall buildings – shows plainly, as do the bridges across the East River

To answer these questions, a group of pilots was selected at random, briefed on the use of airborne radar in a 1-hr session, and flown at night in mountainous terrain on a collision course. Although the tests were conducted at night under conditions most favorable to dim PPI display, most serious collision accidents have occurred at night.

What the pilots saw on the cockpit scope during the simulated terrain collision run is shown in the series of six photographs above. Do you think a pilot could not notice the shadow of a ridge moving in at night? Do you think use of the safety circle requires long schooling?

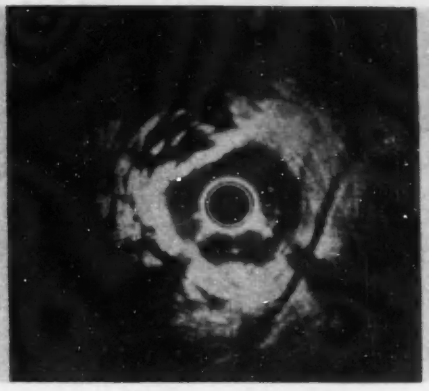
The ability of microwave airborne radar to resolve large ground targets is largely a function of the rotating antenna size. On large transport aircraft it may be practical to use radar antennas as large as 5 ft in the horizontal dimension. Radar operation with a 5-ft antenna over the New York City area, shown in Fig. 1, produced very interesting land-water contrasts on the PPI.

With the pencil-beam airborne radar, the pilot can see and avoid thunderstorms – even when flying over land. Obviously it is impossible to see an echo from a thunderstorm mixed in with ground clutter. The radar antenna can be tilted up or down by a spring-loaded "antenna tilt switch."

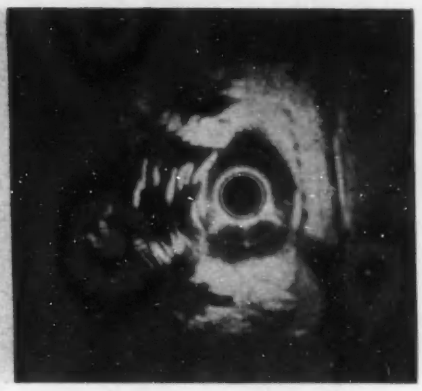
Tilting the antenna upward raises the antenna beam so that it no longer looks downward toward the ground. The beam can be made to look ahead at flight altitude, or can be tilted upward to scan above the flight altitude. Actual antenna tilt with respect to the aircraft is indicated on a "tilt meter"

the Pilot Sees It

4. The plane is now climbing at the rate of 300 ft per min. In this nose-up attitude, the terrain near the river fades out of the radar beam; but tops of the peaks ahead and to the left are still vivid. This shows the plane could not safely climb over the ridge ahead.



5. In vivid display is imminent terrain collision as the pilot sees it. There is still time to turn and avoid the ridge ahead. The safety circle is distorted with the ridge less than two miles away. Avenue of escape is obviously out to the right, bearing 30 through 60 deg.



6. The pilot immediately turned 30 deg to the right when he saw the previous picture. He is now flying parallel to the ridges at the left. Another turn of 20 or 30 deg to the right will assure missing the hills looming up in the scope ahead and to the left.

mounted in any convenient location in the cockpit for the pilot to see.

With the radar beam at 0 deg tilt, the pilot will see on the scope echos from thunderstorms or frontal weather at his altitude.

Fig. 2 shows several mild summer thunderstorms seen by airborne radar with the antenna at 0 deg tilt. Quick evaluation of the various rain areas enables the pilot to pick his way through a region infested with thunderstorms.

Not only will airborne radar work as a search device independent of ground equipment, but it can also interrogate ground radar beacons. The ground beacon is dormant until airborne radar asks it, by means of pulses and the rotating antenna, "What is my range and bearing?" Using pulses a millionth of a second long, the beacon replies, "This is the La Guardia Beacon. You are 62 miles away and my true bearing is 42 deg."

This question and answer radar technique continues at the rate of 400 times per sec. The exchange of information establishes tracks between beacons, the heading of the aircraft on the track, and distance of the aircraft from each beacon on the track. A glance at the radar tube will give the pilot all this vital information on a polar plot.

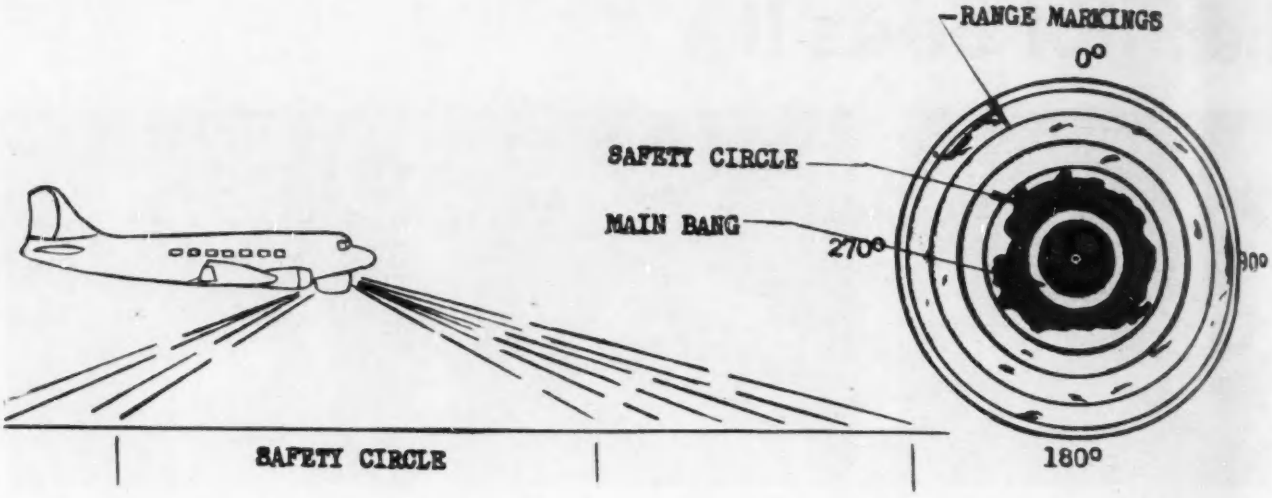
Radar beacons have also been investigated as a navigational device to give lateral guidance when making low approaches to a runway. The radar beacon picture on the tube lends itself admirably to this job.

In present low approach systems, a radar beacon is placed at each end of the runway. This permits low approaches from either direction, using two beacons for lateral guidance only. With each beacon putting out two pulses, accuracy of lateral alignment with the runway is increased.

By looking at the second pulse of each beacon, the pilot approaching the runway can see on the PPI the exactness of his lateral alignment with the runway – but magnified to increase accuracy. He can simultaneously read, on the PPI tube, his distance to the end of the runway from the first pulse of the radar beacon on the approach end of the runway.

While it appears that little remains to be found about how to install and employ airborne radar in transport aircraft, experts on the job feel much remains to be learned to continue the program of enhancing flight safety ➡

Fig. 2 – The airborne radar sees several mild thunderstorms. Almost merging with the main bang is a small echo from a mild shower area directly ahead. Directly ahead of this area is an opening between two other rain areas. The larger is to the right. These areas can be quickly observed and evaluated so that the pilot can pick his way through a thunderstorm-infested area at night



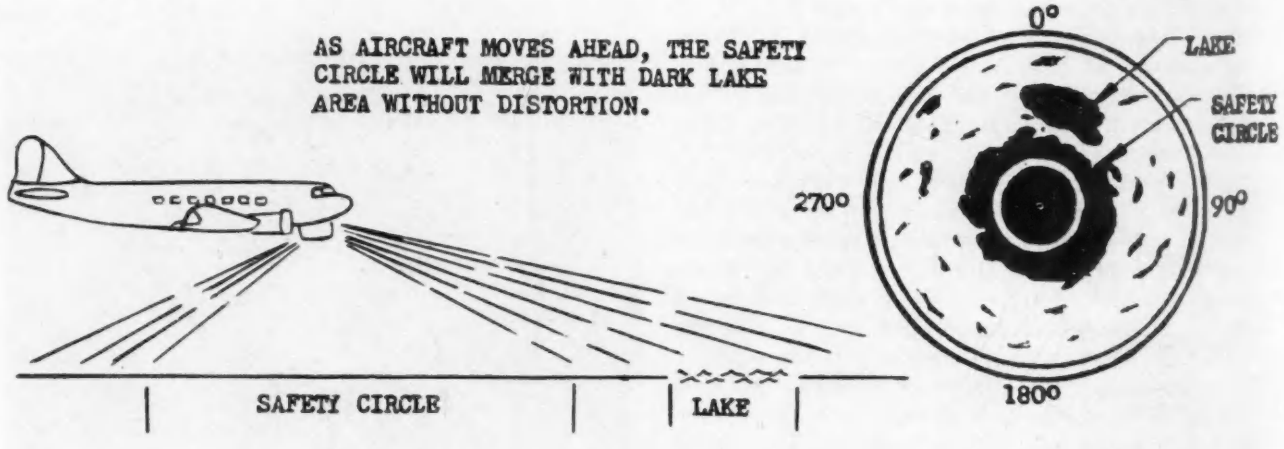
Over Level Land

Shown here is the pencil beam while the aircraft is flying over flat terrain. The pencil beam sends no signal to a cone-shaped area beneath the airplane.

On the PPI cathode-ray display tube – right side of the drawing – exists a dark, no-signal area. It begins at zero range (the first bright circle caused by the transmitter pulse) and extends in range to the distance at which the radar beam first touches ground terrain.

This dark area on the PPI tube has been called the safety circle and is the device by which the pilot is warned of terrain collision.

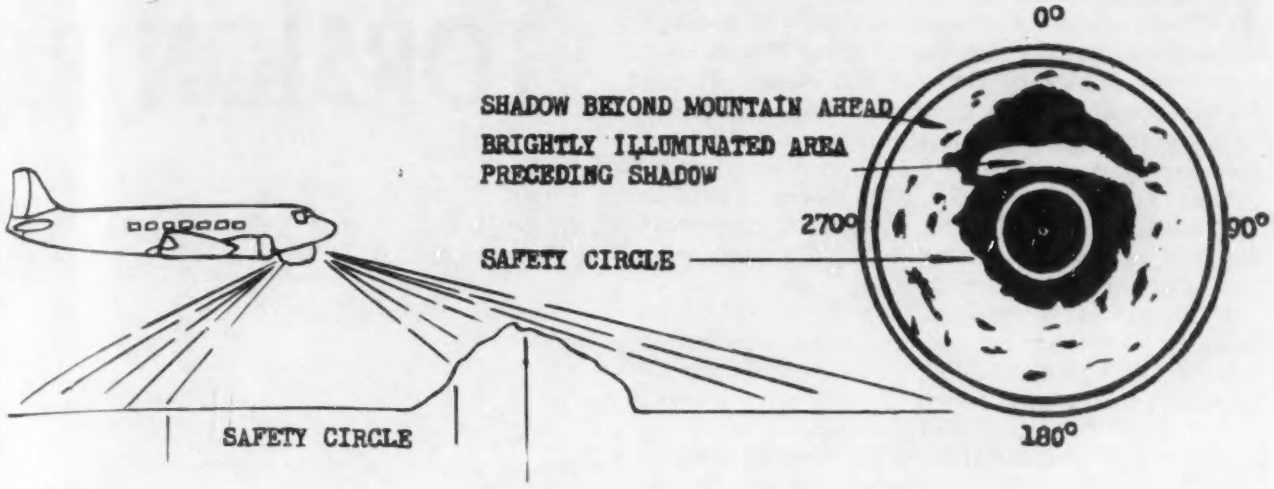
The range markers are concentric circles drawn by the sweep as it rotates on the PPI tube; they divide the total range of the tube to make reading range on the tube easy and accurate. Total distance from the center of the PPI tube to the edge may be selected by the pilot by rotating a range switch. He can choose a total range, for example, of 6, 8, 15, 25, or 50 miles. Range marks of appropriate spacing are automatically selected as the range is changed.



Over Water

When flying toward a lake or a body of water, a dark area appears on the PPI tube showing the shape of the lake and its correct range and bearing. The flat surface of the water is a poor reflector of the radar signal as compared with trees, buildings, and other ground areas which produce a mottled appearance called "ground clutter" on the PPI tube. An example of ground clutter is shown in Fig. 1.

As the aircraft flies toward the lake, and the lake approaches zero range, the dark area on the PPI tube will merge with the safety circle.



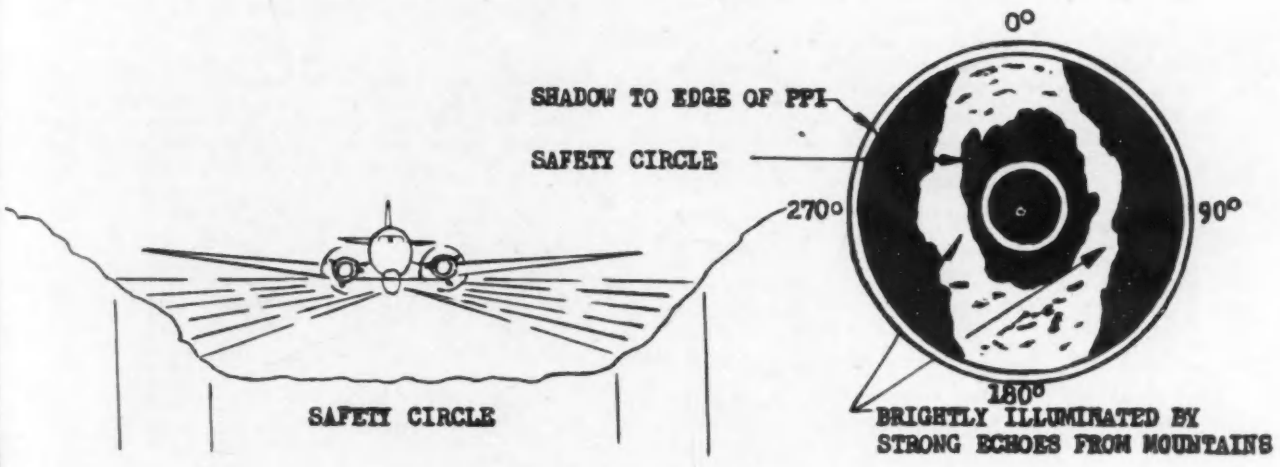
Over Hills Here the airplane is approaching a hill at an altitude above the top of the hills. Echoing of the radar beam off the rising hill slope creates a bright signal on the scope. This bright signal is not sufficiently arrestive to be considered a terrain collision indication in itself.

The safety circle is pushed in on its leading edge. This together with the dark area behind the bright echo is the obvious terrain collision indication. The dark area corresponds to the area behind the hill where the radar beam cannot reach the ground.

Note that this drawing shows the case where the aircraft is dangerously near the hill top, but will pass over it. The safety circle is pushed in, but the ground is seen beyond the hill top.

Within a few seconds of flying, the echo of the leading edge of the hill will become shallow and fade if the aircraft is sufficiently high above the hill top.

But when the safety circle is pushed in and the shadow area behind it extends to the edge of the PPI screen, terrain collision is a distinct possibility. The pilot can see sure death approaching as the bright leading edge of the echo from the hill moves toward zero range. But he has ample time to turn or climb.



Between Mountains This was copied from an actual photograph of a PPI display taken in the Blue Ridge Mountains, with the airplane flying below the tops of parallel ridges. Note the ease with which the pilot could find his way down the slot between the ridges, using the safety circle and PPI display to advise him of the distance to the ridges.

It makes possible flying below ridges. This may be necessary in emergencies such as loss of an engine or in severe icing or thunderstorms, when the plane cannot maintain altitude to fly over the top.

(This paper will be published in full in SAE Quarterly Transactions)

TORSION BAR
Soft

ANALYSIS shows that the torsion bar more than other suspension designs approaches the optimum toward satisfying the cardinal objectives of passenger and driver comfort and safety. Torsion bar suspensions keep unsprung weight low; protect against sidesway instability; provide easy steering; and minimize road-bump discomfort.

What is a comfortable ride? Somewhere between the hard, jarring ride of a too-stiff suspension and the nauseating ride of a slow-pitching ocean liner lies the answer.

H. S. Rowell hit the nail on the head in 1923 when he said that, through the ages, internal organs of the average human being had become accustomed to walking at 2 to 3 mph, with about a 30-in. step. This is equivalent to 70.4 steps per min at 2 mph and 105.6 steps per min at 3 mph.

The fact that most modern passenger car suspensions have a designed frequency of 70 to 90 oscillations per min – a designed frequency less noticeable to the human body – bears out this theory.

At this point the medium of suspension – the spring – comes into the discussion. The spring is used because it can store energy and return to its original shape or position upon release of an applied force. Release or sudden increase of this force vibrates the spring with a certain number of oscillations per minute.

All-important in its effect on ride and, therefore, on the spring, is the unsprung-to-sprung-weight ratio. The following formula illustrates the point:

$$E = \frac{mV^2}{2g}$$

Where:

E = kinetic energy
m = the mass
V = velocity
g = acceleration due to gravity

Obviously any increase in "m" increases E. The increase from the movement of the unsprung mass in passing over a bump would require the spring to store more energy; the body would have to

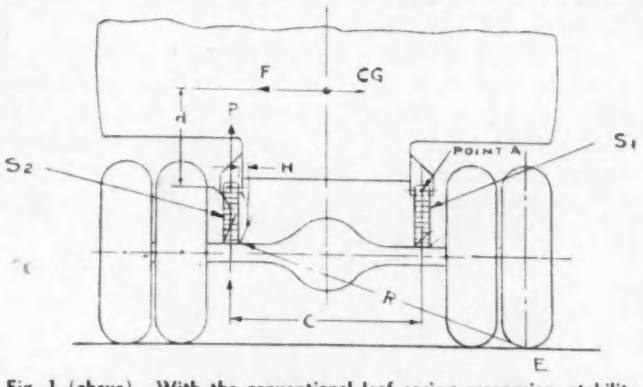


Fig. 1 (above) – With the conventional leaf spring suspension, stability is decreased as "d" – the distance between the spring and the c.g. – increases due to spring deflection

Fig. 2 (below) – The suspension linkage for a torsion bar is close to the c.g. so that the distance "d" does not increase with vehicle roll, maintaining stability

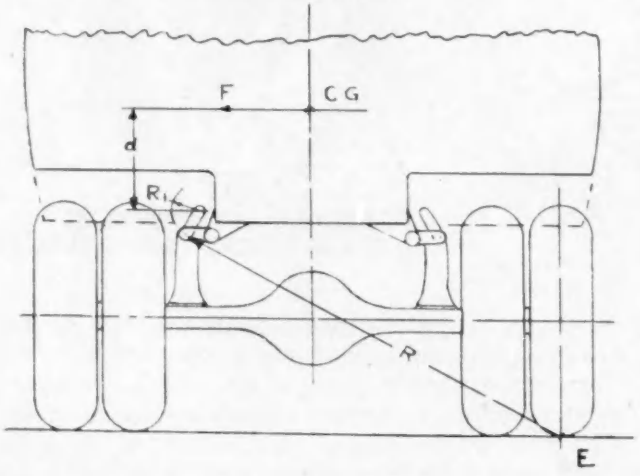
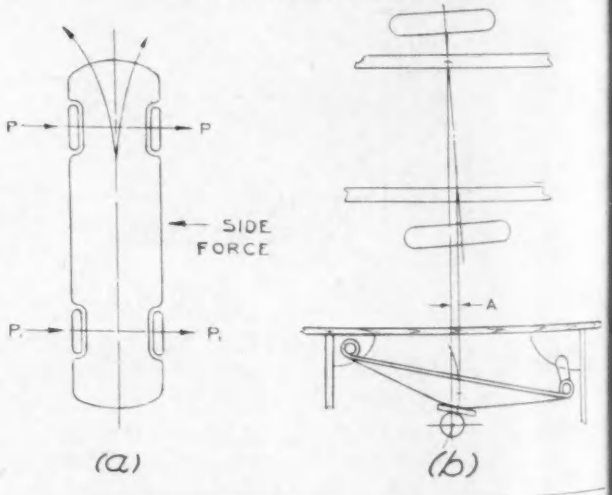


Fig. 3 – Side wind acting on the vehicle in (a), with unequal weight distribution on both axles, will tend to turn the vehicle from its course. Sloping the spring, in (b), remedies the condition. In a roll, the body compresses the spring on one side, forcing that axle back, so that it provides a corrective steering action



ASSURES
and Stable Ride

BASED ON A PAPER* BY

N. E. BATESON

Project Engineer General American Aerocoach Co.

resist a greater vertical force. As the body's weight decreases, its ability to resist this force without changing its horizontal position also decreases. These two deductions are demonstrated in day-to-day driving. The ride in a loaded vehicle is much more comfortable than in the same vehicle when it's empty.

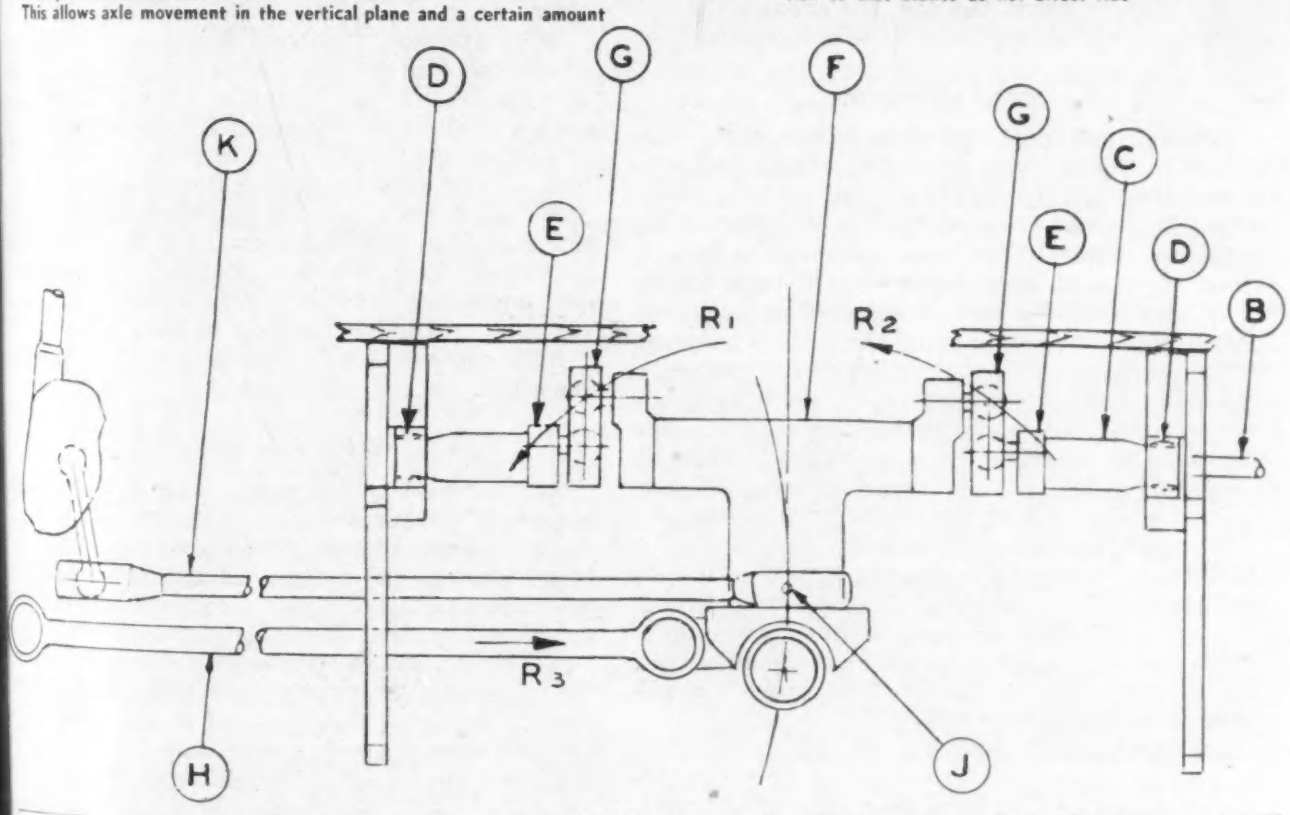
The torsion bar suspension has gone a long way toward reducing unsprung weight by removing the spring from the axle. In the case of a bus rear-end suspension, the springs weighed 220 lb each; yet the bracket for the torsion bar weighed only 50 lb. This reduced the unsprung mass by a total of 340 lb.

Just as riding comfort is dependent on spring flexibility or oscillations per minute, stability is determined by spring stiffness or its ability to stop

*Paper "Problems in Commercial Vehicle Suspensions and Their Elimination by Torsion Bars," was presented at SAE National Transportation Meeting, Chicago, April 17, 1947.

Fig. 4 – Torsion bar suspensions provide nearly perfect steering geometry and fully controlled axles. Torsion bar B is carried in tube C, which is mounted on a frame with spherical preloaded bearings to compensate for manufacturing misalignment and frame deflections. Tube arms E are attached to axle bracket F by links G, connected by preloaded spherical ball studs.

This allows axle movement in the vertical plane and a certain amount of lateral movement. Radius arm H controls the axle in its lateral plane. The radius arm front-end is located so that steering ball J arcs in a perfect radius with steering drag link K. Elimination of road shock transmission to the steering wheel lessens driver fatigue and lengthens gear life. Linkage resistance R_1, R_2, and R_3 take out brake torque reaction so that brakes do not affect ride



rolling. Both comfort and safety demanded from a spring impose conflicting requirements.

In the past ride was sacrificed to make the vehicle safe. If comfort was desired, antisway tubes or bars were installed.

The sprung mass c.g. in the commercial vehicle is high compared to the passenger car. In a bus it's 2 to 6 in. above the floor. Ideal spring location to stop roll from centrifugal forces in cornering is at the horizontal c.g. But since springs must be placed beneath the floor, this is not possible.

Fig. 1 shows a conventional leaf spring suspension. Spring S_2 resists the centrifugal force F, due to cornering, acting at the c.g. Taking moments about A, C x P (clockwise) = d x F (counterclockwise).

If the spring is raised, "d" is decreased so that the moment dF requires a smaller resisting force P. And as the springs are spread apart, or as C increases, P is decreased proportionately. As the spring deflects, "d" increases and the vehicle tends to lose its stability.

Effect of spring location on the spring itself also is shown. When the left wheel goes over a bump, it travels in a radius R with a center point at E. This foreshortens the distance between springs at the axle by H. It also applies a side force on the body which, together with an excessive bump on ice, can start a skid.

Were it not for flexibility of rubber bushings, the resultant twist of dimension H on the spring eyes would shorten spring life and take its toll in tire wear to offset this force. The higher the spring is mounted to resist the roll, the greater the side forces and spring eye twist to be compensated for.

Effect of Linkage

Linkage design in the torsion bar suspension, shown in Fig. 2, overcomes these difficulties. The suspension linkage can be built high into the wheel house and close to the c.g. As the vehicle rolls, the distance "d" does not increase to help force F. The shackle angle is such that, as the body moves to the side, it applies an added resisting force by moving along the path of radius R.

Spring height determines shackle angularity. Placing the shackle tangent to radius R (with its center at E, the intersection of the opposite wheel's centerline and the ground) practically eliminates all side forces from road irregularities. We get both comfort under vertical shocks and cushioning against accompanying sidesway.

One experimental bus equipped with torsion bars can make a 90-deg turn at 50 mph with all six tires sliding on dry concrete, without any appreciable roll. It's possible to sit in the rear seat of this bus, overhanging the rear axle, and drink coffee without spilling it at 70 mph.

Suspensions and steering go hand in hand. Any steering geometry should be judged on its reduction of driver fatigue. The much-discussed understeer and oversteer problems resolve themselves into a study of the vehicle's ability to maintain a straight course without assistance from the driver.

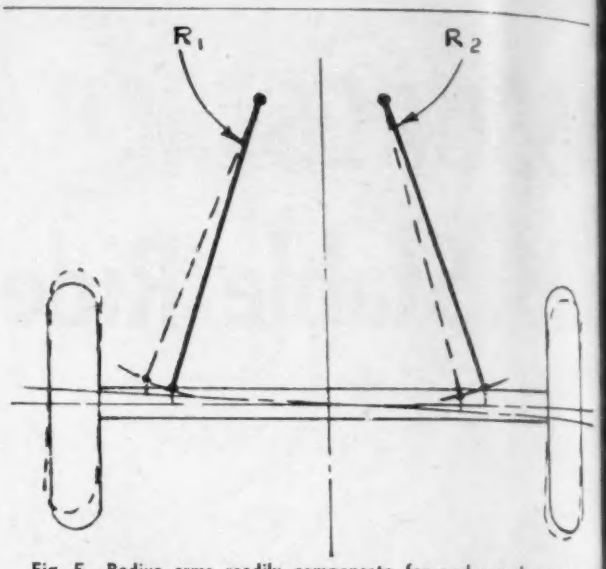


Fig. 5 – Radius arms readily compensate for under and oversteer

Any vehicle on pneumatic tires changes course only by transmission of steering gear or external forces through the tires. Ability of tires to resist or apply cornering forces to the vehicle is proportional to the weight they carry. With side wind on a vehicle having unequal weight distribution on single front and rear tires, either the front or rear axle will tend to hold its course more than the other, as in Fig. 3 (a).

With oversteer, the vehicle will tend to go out of control after passing a certain critical speed due to centrifugal force. This condition should be corrected in the steering geometry or suspension if proper weight distribution cannot remedy it. It was usually done by sloping the spring, as in Fig. 3 (b). The body compressing the spring on one side only, due to roll, forces the axle on that side backward. This causes a steering action due to axle angularity, as in the plan view.

Providing torsion bars, as in Fig. 4, makes for a fully controlled axle and near-perfect steering geometry.

Radius Arm Action

Radius arms readily compensate for under and oversteer. Side clearance between the chassis and spring bracket allows the body to move sideways in relation to the axle, until the link resistance overcomes side force. Fig. 5 shows the side movement used by the radius arm angularity.

As the body moves sideways, radius arm R_1 pulls the left side of the axle forward and arm R_2 pushes the right side of the axle backward. This makes the axle steer in such a way that external forces are counteracted and the vehicle tends to keep

concluded on page 37

HERMETIC SEAL Increases Life of Aero Instrument

BASED ON A PAPER* BY **W. A. REICHEL**
Vice-President, Kearfott Co., Inc.

ENGINEERS have struggled for years with the problem of protecting delicate instruments from the elements. Many ways of attaining protection have been devised. Often they have been quite successful for limited applications. They have taken the form of protective coatings, of making parts from corrosion-resistant materials, and of enclosing the whole mechanism in a tight compartment. Recently, the last hurdle was overcome, namely, that of hermetically sealing the instrument that requires adjustment or regulation.

How this progress was attained will be outlined briefly, covering early efforts of various kinds, and culminating in the surest, the most positive, and the most dependable method – that of sealing metal to metal or glass to metal without gaskets, and called hermetic sealing.

Early Efforts

The idea of protecting instruments in hermetically sealed cans has been used for a long time. Even during World War I radio equipment was shipped all over the world in cans, sealed hermetically like a can of sardines.

In the early years of World War II, particularly in the South Pacific, it was extremely difficult to maintain equipment in operating condition because of dirt, dust, moisture, fungus growth, and salt air.

As a matter of fact, 1943 Navy records indicate that 95% of the failures of electrical equipment in instruments were due to these causes and only 5% were due to mechanical failures and electrical breakdown.

Equipment was made out of corrosion-resistant materials wherever possible, but this was a limited solution because certain key parts, such as pivots for instruments, ball bearings for gyros, and laminations for magnetic structures, could only be made from materials that unfortunately do corrode.

Many types of plating techniques and paints were developed, which did an excellent job of protecting the surfaces as long as the protective coating remained undamaged. Finishes were devolped that arrested the growth of fungus temporarily. Various inhibitors for lubricants were tried out to arrest oxidation of the lubricants and thus prevent corrosion of vital parts.

Meanwhile, several manufacturers of radar

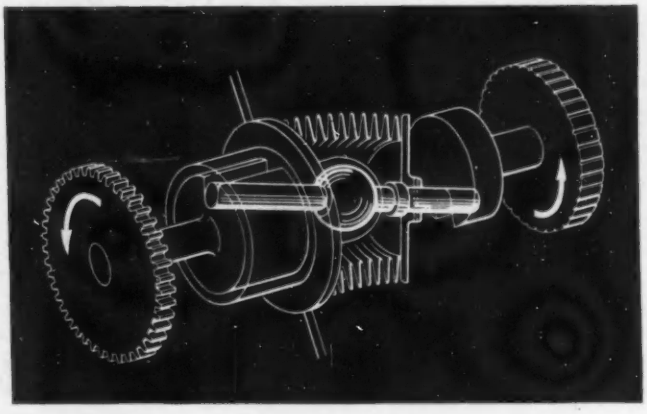


Fig. 1 – Hermeflex unit designed to transmit rotary motion through a positive, metal-to-metal seal

*Paper "Hermetically Sealing Aircraft Instruments and Control Components" was presented at the SAE National Aeronautic Meeting (Spring), New York City, April 11, 1947

amplifiers decided that instead of trying to make their parts withstand severe climatic conditions, it would be better to enclose the equipment in a metal container, sealed with rubber gaskets, and then kept filled with dry air under pressure. This was a good remedy, but the tightness of the joint and perfection of the gasket had to be checked continually.

Hermetic Seals

A study of the problem indicated that hermetic sealing of the whole equipment, or at least of the electrical components, would be better because then we could create the exact desired laboratory condition inside the container (with the exception of temperature) and the instrument would be affected by neither moisture nor high altitude.

There are several ways of obtaining hermetically sealed containers. We all know that the glass container used for vacuum tubes is successful. The glass and metal container used for large power X-ray tubes is also quite satisfactory. The hermetically sealed headlights on our cars have all but eliminated headlamp failures.

Sealed terminals are now successfully used for leading electrical circuits through the hermetic seal. Basically, they consist of metal fused to glass of substantially the same coefficient of expansion. They are available in various sizes and shapes as a subassembly called a header, which is easily soldered to the container in which it is to be used. Thus the hermetic sealing of condensers, transformers, and relays is now a comparatively simple problem.

Metal fused to glass has also been used to seal electrical indicating instruments or devices like gyros, whose positions must be observed in their containers, but this method has necessitated a rather thick glass and an expensive fusing operation.

More satisfactory is a method of fusing silver to glass to form a strong bond. The silver coating is then thinned and the piece of glass soldered to the container.

Until about two years ago the protection afforded by this type of seal was not available for instruments requiring adjustment, because they could not be regulated after they were sealed. At that time a small unit that allows motion to be transmitted through a metal-to-metal seal was perfected.

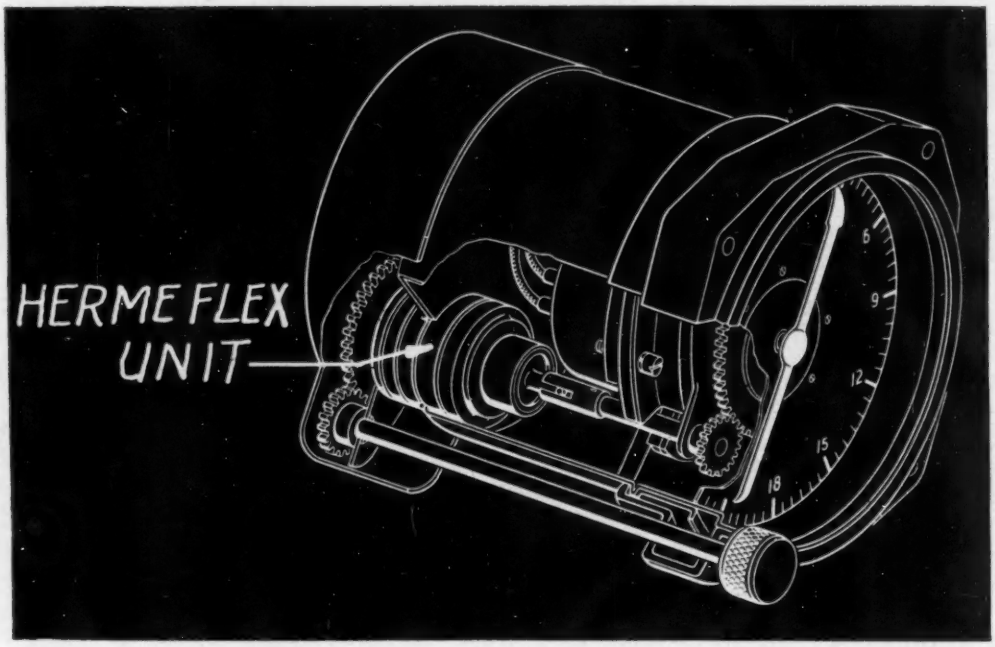


Fig. 2 – Remote-reading indicator can be hermetically sealed because rotatable dial is adjusted through hermeflex unit

The principle of this unit – called hermeflex – is shown in Fig. 1. Fig. 2 shows how the unit has been applied to a remote-reading indicator.

The unit consists of a pivoted shaft sealed in a metal bellows to provide the necessary flexibility. The shaft oscillates like the oars of a man rowing a boat. One end of the shaft is driven in a circle. Because the shaft is pivoted, the other end also describes a circle.

This method of providing protection is a big improvement over the use of packings and gaskets. No matter how good a gasket is you never know when it is going to fail. It deteriorates with age and vibration, but the basic trouble is that the coefficient of expansion of gasket material is at least twice that of any metal – and airplane instruments must be able to operate over a range of –75 C to 85 C (–85 F to 185 F).

Gaskets just can't be counted on to give the proper protection, for in delicate instruments even the smallest leak can't be tolerated.

A gyro left in a room of ordinary cleanliness would require a complete overhaul in six months even though the temperature varied but slightly. By this time the lubricants in the precession bearings would be oxidized and gummed to the point where the accuracy of the gyro performance would be seriously impaired.

Contrast this with the performance of one gyro that was hermetically sealed in dry nitrogen, and ran continuously for two years and 10 months.

Special Features

Several interesting developments have made this sort of service record possible.

For instance, the instruments are checked for leaks with a leak detector capable of indicating the escape of 1 cc of helium in four years at atmospheric pressure. If the instrument shows no leaks with this detector (originally made by GE for use in connection with the atomic bomb), there is reasonable assurance that the gas in the units will remain for the life of the instrument, since there are no gaskets in the assembly to cause trouble.

This method of detecting leaks solves a problem that had long proved troublesome. Dunking the whole assembly in a pail of water or even gasoline and watching for bubbles does not detect a slow leak. One not very satisfactory system consisted of putting the completed instrument on the shelf for 30 days. If the cell didn't swell in that period it was considered satisfactory. Unfortunately, sometimes a leak would show up a year after the instrument was delivered.

Another important feature is the elimination of trapped water vapor in such parts as the insulation and coils. This is done by baking the equipment up to 85 C (185 F) for a few hours while maintaining a high vacuum.

Assembly of the units is not difficult. The parts of the housing are joined together by soldering. Induction soldering is a quick and easy method of accomplishing the job. In fact it is simpler to solder the case than to put a couple of dozen screws in an old-fashioned case to tighten a gasket.

Servicing these devices does not cause trouble, for the work of opening and closing one of the cases is much easier than, say, balancing a gyro or adjusting sensitive altimeters, which was widely done in the field on military equipment.

One should not forget that the need for opening the case becomes much less frequent than for the unsealed type. The equipment is now protected against the 95% failures caused by the elements, so that servicing will be required only about one-twentieth as often. Another important point to remember is that even if the equipment is exposed to the atmosphere by, for example, a bullet going through the case but not damaging the equipment, we still have a brand new instrument in contact with the same elements to which the standard equipment of two years ago was continuously exposed. In other words, it will not stop operating immediately – and it will bring the pilot home.

Designing for Hermetic Sealing

On the surface, it might appear simple to take existing equipment and hermetically seal it in a container. Such an installation would, however, be bulky and heavy. To do the job right, it is necessary to design the instrument with hermetic sealing in mind. For instance, the use of dry neutral gas in the container means the maintenance of uniformly high dielectric insulations. This allows high impedence circuits to be used, which bring down the size and weight. If helium is used for the gas, there is also an improvement in heat dissipation.

It should be possible to start redesigning for hermetic sealing immediately, because the tremendous progress being made in aviation has already obsoleted the instruments of even five years ago.

■

TORSION BAR

continued from page 34

straight course. Designers in the past relied on front-axle caster to return the wheels to a straight-ahead position after cornering. With radius arm control, caster was found to be unnecessary and steering effort is much lighter with zero caster.

This geometry achieves a more sensitive and positive steering gear because it eliminates items such as rubber bushings and spring camber that allow the axle to move before the wheels turn, when a load is applied through the drag link.

Efforts to damp effects such as wheel tramp and shimmy with soft suspensions drove engineers to many cures, none of them too good. Advent of independent suspensions in cars with fully-controlled wheel movements and rigid frames made the wheel hop vertically. The soft suspension and damping could control this vertical hop with little effect on the body. Presence of lateral motion in the hop is what disturbed the ride.

Other advantages that can be claimed for the torsion bar over leaf spring suspensions are longer life and reduced maintenance.

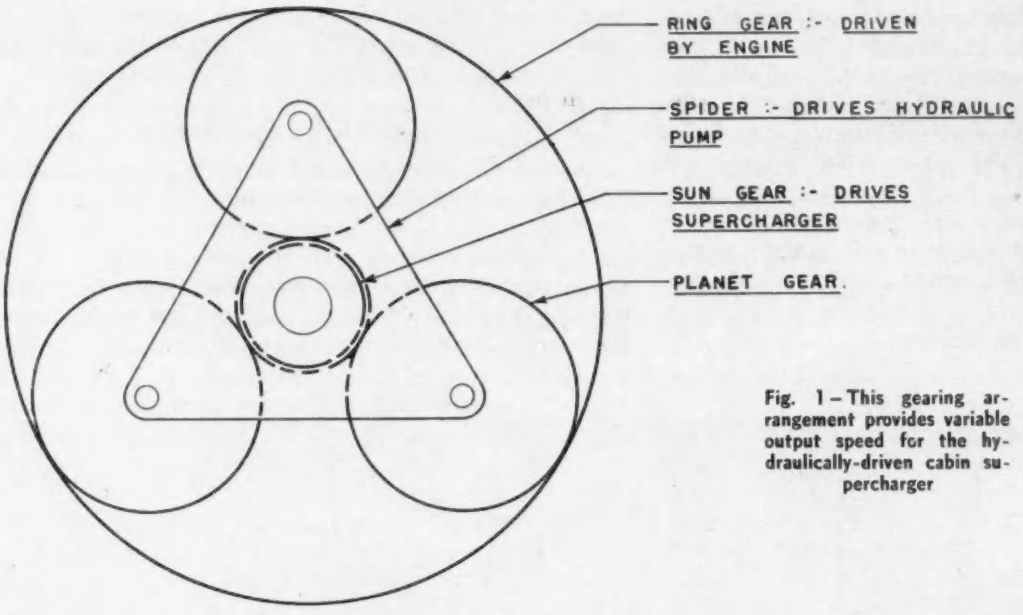


Fig. 1 – This gearing arrangement provides variable output speed for the hydraulically-driven cabin supercharger

THE DC-6 cabin supercharger drive now in quantity production scored an initial success for hydraulic power's penetration of the high-speed rotary equipment field, normally dominated by electricity. Ten years of experimenting with hydraulic powerplants imparted the know-how that made this achievement possible.

When work first started on application of hydraulics to high-speed cabin supercharger drives, it was intended for the DC-4 air conditioning and pressurization system.

The system in its original form took power to drive the supercharger directly from the main engines through a flexible drive shaft. A variable-speed drive was selected because of temperature rise through the blower, power consumption at high engine speeds, and the requirement of supercharging at low cruising speeds of the engine.

Hydraulic means were used to provide the variable speed, and it also offered appreciable vibration isolation and convenient protection against transient overloads.

Variable speed was provided simply, as illustrated by Fig. 1. The ring gear was driven by the engine at a speed dictated by engine operating requirements. The ring gear drove planet gears. These in turn, drove the sun gear, which was integral with the supercharger impeller shaft. The planet gears were tied together by a spider, which drove a hydraulic pump – known as the "slip pump" – since the faster it turned, the slower the supercharger turned. With this arrangement, the torque tending to turn the pump is a fixed ratio times the torque tending to turn the supercharger.

Since a pump driven at constant torque delivers constant discharge (neglecting the effect of efficiency), the addition of a relief valve from pump outlet to inlet yielded a drive providing essentially constant torque input to the supercharger.

Schematically, it would seem equally practical to drive the spider from the power source and to control the speed of the ring gear by means of the hydraulic pump. This might lend itself to a more compact arrangement.

But the engine usually delivers its accessory power at quite a high speed; the spider preferably runs slowly because the planet bearing loads – largely due to centrifugal force – are directly affected by its speed. The pump is also an essentially low speed device, so it was more logical to connect the pump and spider than the pump and ring gear.

A schematic diagram of the complete, prewar system is shown in Fig. 2. By using the engine oil tank as the main reservoir for the system, the heat generated by pumping oil through the relief valve was rejected to the regular engine cooling system. The added cooling load was less than 5% of the design capacity of the system, reaching its peak when the engine cooling requirements were low.

High flow rates were sometimes encountered which might cause foaming in the oil tank or excessive suction-line pressure drop and cavitation in cold weather. A low pressure bypass valve was added within the relief valve-pump assembly so the amount of oil circulated through the oil tank was considerably reduced. Sufficient flow to provide the necessary cooling remained.

A bleed orifice was built into the relief valve

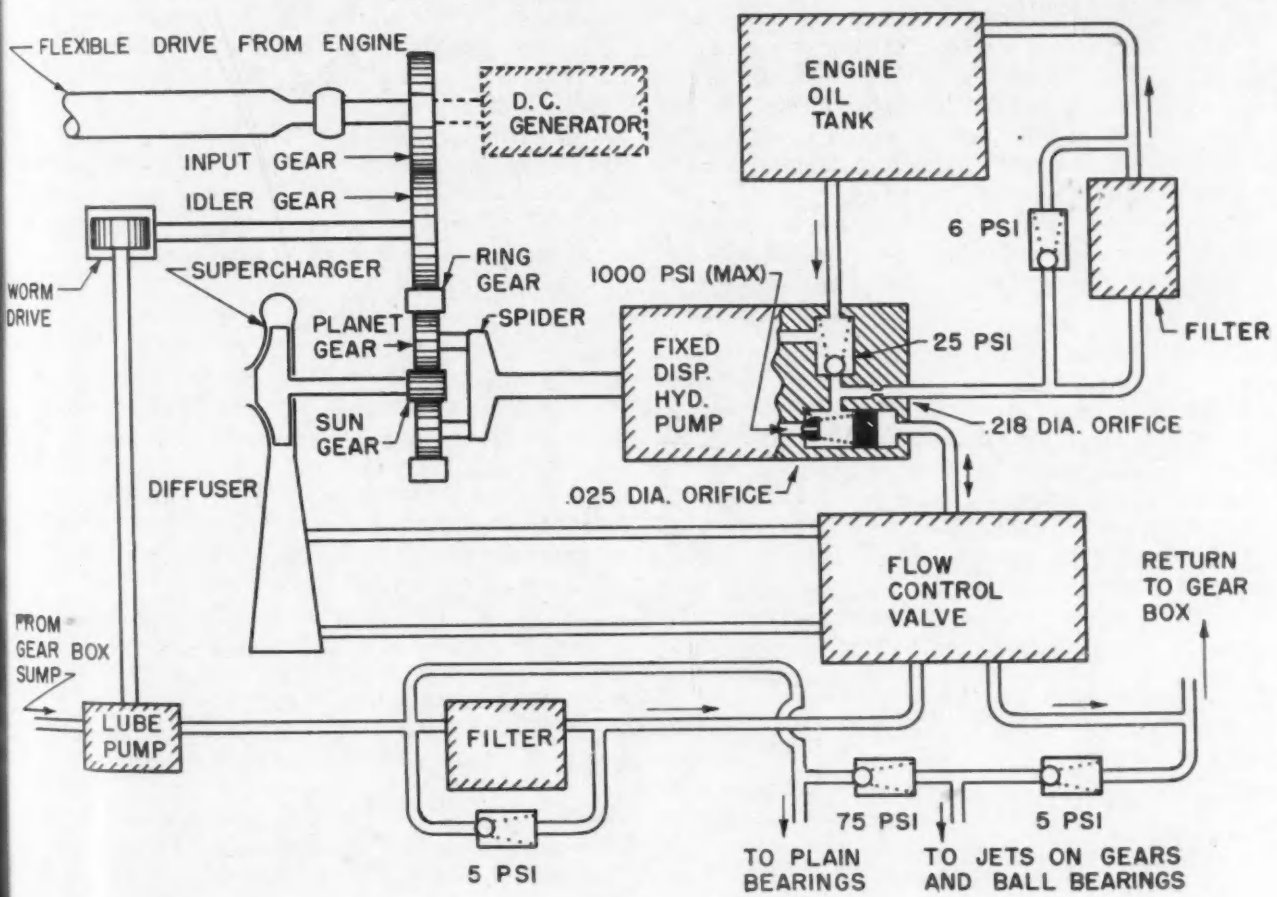
* Paper "Some Applications of Hydraulics to High-Speed Rotary Drives for Aircraft Accessories," was presented at SAE National Aeronautic Meeting (Spring), New York, April 11, 1947.

Hydraulic Rotary Drive to DC-6 Cabin Supercharger

W. W. THAYER

Engineer, Air Conditioning Group, Douglas Aircraft Co., Inc.

Fig. 2 – Schematic diagram of the cabin supercharger drive developed for the DC-4



piston, so that the pump could not overheat by operating at slightly less than the cracking pressure of the relief valve.

A study of the supercharger characteristics at constant torque indicated that the temperature rise of the cabin ventilating air at sea-level, hot-day conditions was considerable. But it could be greatly reduced if the torque were reduced under these operating conditions. For this reason an automatic control valve was introduced. It changed the relief valve setting required to maintain delivery of an approximately constant weight flow of air.

This in turn reduced the torque at all conditions until the maximum compression ratio was reached, correspondingly reducing the temperature rise and power taken from the engine. The cabin pressure control system was not affected by this change, because the pressure in the cabin (and thus the pressure at the outlet of the supercharger) was controlled by an outflow valve from the cabin. Control system of this valve is entirely independent from the flow control system of the supercharger.

The actual gear box incorporating the variable-speed planetary drive required two more gears than shown in Fig. 1, to provide both a means of driving the ring gear and clearance for an electric generator. The generator was mounted on the gear box rather than the engine as a matter of convenience. It was also necessary to provide a gear-type lubrication pump driven by a worm.

Development and testing of this system progressed through a life test, run on the automotive engine test stand, and on through another life test, run on a test nacelle behind an airplane engine. At this point the war brought a sudden halt to pressurization plans for the DC-4.

When the war was over, there were some new and radically different ideas about what a supercharger was supposed to do. And there was a very much faster, more highly pressurized, and somewhat larger airplane to do it for – the DC-6.

Jet engines developed during the war were capable of driving airplanes at such speeds that cockpits became uncomfortably hot due to the impact temperature of the air. Availability of high-pressure air in the jet engines gave impetus to the development of refrigeration turbines capable of lowering cabin temperatures well below outside air temperatures.

Obviously, nothing short of year around comfort is worth building into a long range passenger airplane like the DC-6. Therefore, a complete air conditioning system, including cooling, was engineered into the airplane and proof-tested for passenger comfort in the laboratory well in advance of delivery schedules. A schematic of this system is shown in Fig. 3.

The whole system was built around the supercharger power package that had been developed before the war for the DC-4. The supercharger that delivered pressure for cabin pressurization at high altitude, delivered pressure for air cycle refrigeration at low altitude and for both refrigeration and pressurization at intermediate altitudes. The maximum power demands for refrigeration and pressurization were quite evenly matched, with their peaks representing some increase over the original design requirements of the DC-4.

This increase required running the supercharger at slightly higher speeds; but it was not as great a change as the additional requirement of providing these speeds on the ground, without exceeding a practical engine idling rpm to provide ground cooling of the cabin.

At cruising speeds a "slip pump" system would have rejected excessive horsepower as heat. It would have required an entirely new planetary gear box capable of providing higher step up ratios. Fortunately, a large amount of development work had been done during the war on variable

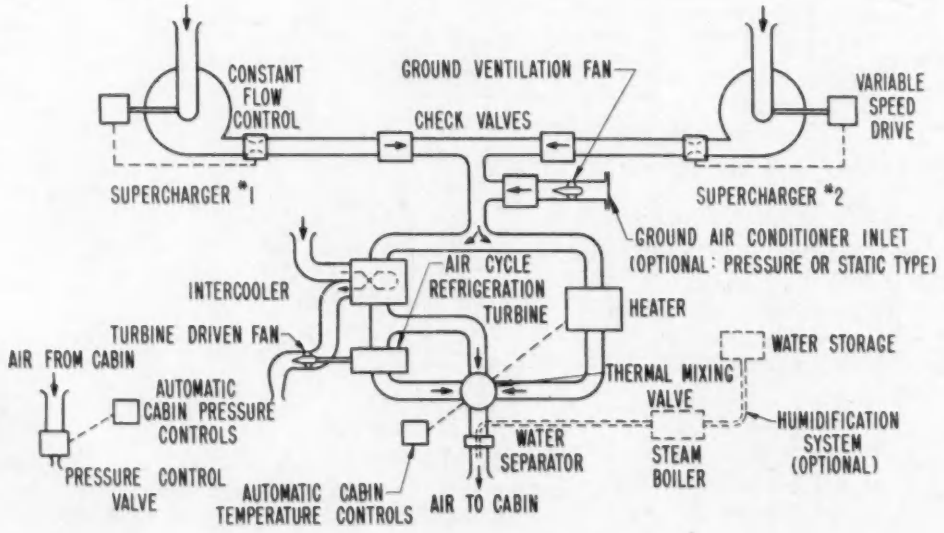


Fig. 3 – Based on the pre-war development for the DC-4, this year-round cabin air conditioning system was built for the DC-6

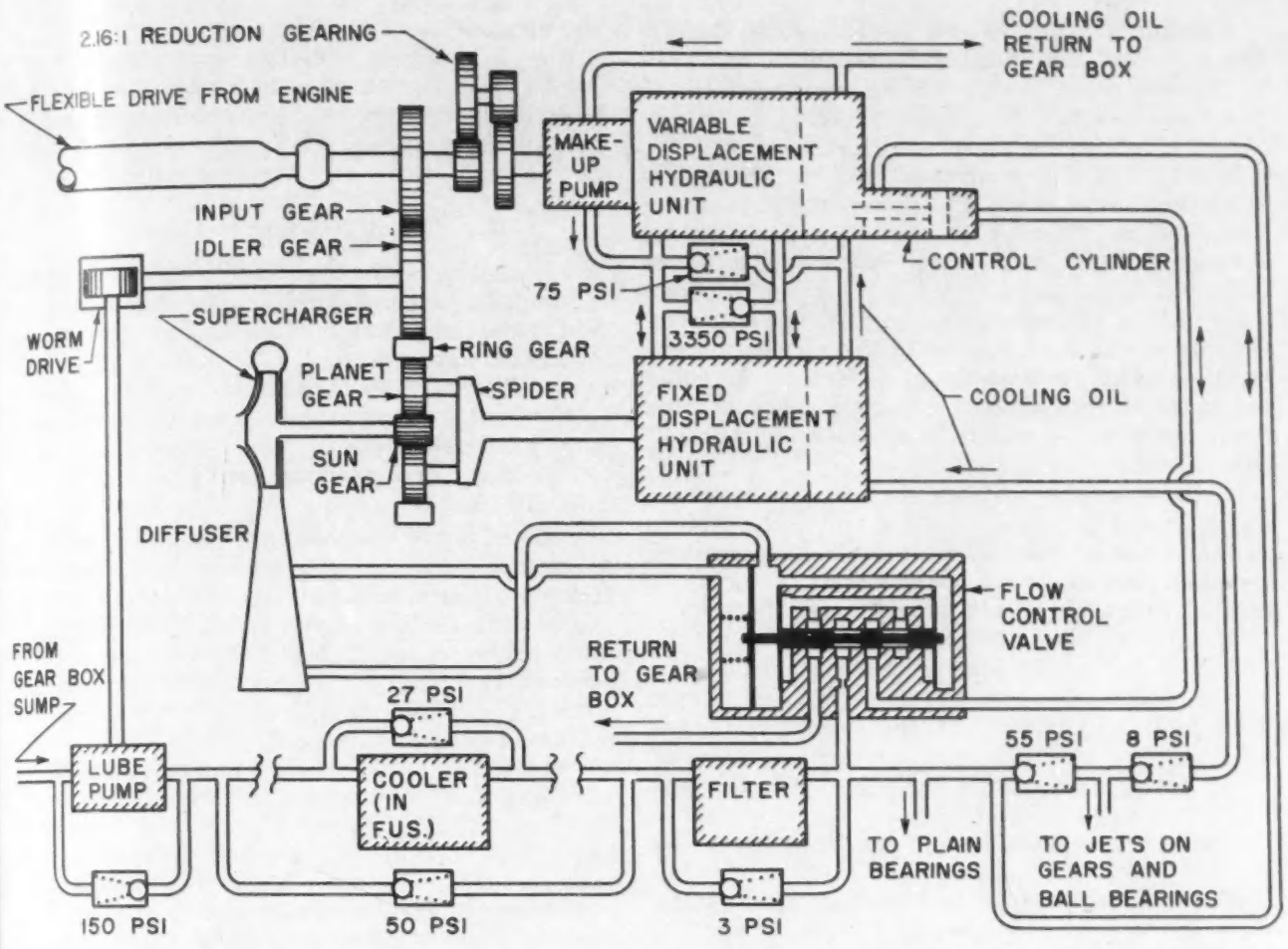


Fig. 4 – This is a schematic of the DC-6 cabin supercharger drive

displacement pumps for gun turrets and aircraft hydraulic systems. The logical outgrowth of this situation was the system shown by Fig. 4.

The basic mechanical component that had been developed for the DC-4 was used as the foundation. Power was delivered from the engine through a flexible drive shaft to an input gear, through an idler (which drove the lubrication pump through a worm drive), to the ring gear. As in the "slip pump" arrangement, the spider was attached to a hydraulic unit, and the sun gear to the supercharger.

Basic difference was that the unit attached to the spider could run in either direction; in one direction as a pump to slow down the supercharger (as in the "slip pump" system), or in the opposite direction, as a motor, to speed it up.

When acting as a pump, it delivered its power to an "overcenter" variable-displacement unit, which, under these conditions, acted as a motor feeding the power back into the drive shaft. (Because of the high speed of the drive shaft in this application, it was necessary to connect the variable-displacement unit to the drive shaft through reduction gears.) When the fixed-displacement unit acted as a motor, the variable displacement unit – overcenter in the opposite direction – pumped power into it.

Due to the overcenter feature of the variable-displacement hydraulic unit, the same line joining the two hydraulic units is always the high pressure line, and the opposite line is always the low pressure line. It is thus possible to provide a relief valve between these two lines, and to limit the maximum torque that can be developed during sudden accelerations of the engine; they might be too rapid for the flow-control system to follow.

The flow control system is exceedingly simple. Filtered hydraulic oil from the gear box pressure lubrication system is supplied to a lapped slide valve, actuated by air pressure across a diaphragm opposing a spring load. The two pressures acting on opposite sides of the control diaphragm are taken from taps on the conical supercharger diffuser, at two different cross-sectional areas. Depending on whether the pressure differential across these two taps is above or below the desired value, the slide valve moves to port oil into or out of the control cylinder. This moves the cylinder-block of the variable-displacement unit in the direction which will tend to restore the desired flow conditions.

A spring might have been used to return the control piston in the variable displacement unit; but in this design, it has been more convenient to use a constant hydraulic pressure working on the "small side" of the piston.

The type of flow control offered by this system is neither constant weight flow nor constant volume flow, but essentially constant ρ_v^2, or constant velocity pressure in the duct system. This seems to be entirely satisfactory. It simplifies the controls; keeps the pressure drop of various components of the duct system in the airplane essentially constant; and seems to do well in matching the curve of best supercharging efficiency at high compression ratios where it is important to minimize power.

A slight amount of restriction in the hydraulic supply to the flow control valve and some overlap on the piston of this valve are all that is required to make the controls operate satisfactorily in parallel with a duplicate supercharger system.

To improve the life and performance of the hydraulic units, the low pressure hydraulic line between them is pressurized to 75 psi. In the case of the hydraulic powerplant, this pressurizing task had been very burdensome, since the entire flow of the pumps had to pass through the booster pump. In this new application, the same oil circulates continuously between the two hydraulic units in the so called "bridle circuit." A small capacity makeup pump, which replaces the leakage from the system, and a 75-psi relief valve are all that is required to maintain the low-pressure line at the desired pressure.

Fig. 4 also shows the lubrication and cooling system for the gear box and hydraulic bridle circuit. A lubricating pump is driven from the idler gear through a worm drive. It pumps oil through a cooler, located in the fuselage, and through a filter. This high pressure oil is supplied to the bearings and supercharger flow control circuit. Oil at a reduced pressure is supplied to various cooling and lubricating jets built into the gear box. The remaining oil is flushed through the cases of the hydraulic units to carry away excess heat.

It may seem odd at first that the oil cooler is remotely located in the fuselage, while the rest of the equipment is in the outboard nacelles. Very little cooling is required at all except during sea-level, hot-day conditions. The dual superchargers are then taking in hot air, compressing it until it is over 200 F, and delivering it to the single aftercooler and expansion-turbine refrigeration unit centrally located in the fuselage. The expansion-turbine must do work to drop the temperature of the cabin air. This work is done driving a fan which pulls air across the aftercooler and, at the same time, across the oil cooler unit.

In this manner, the cooler is assured of sufficient air flow when the refrigeration system is running, even if there be no forward motion of the airplane to provide ram air.

Fig. 5 shows a complete supercharger power package. In the picture are visible the main gear box, the supercharger, the reduction gear box, the variable-displacement hydraulic unit, the bridle-circuit relief valve and the flow control valve.

Typical Hydraulic Problems

An example of the hydraulic problems to be considered in a design of this kind was the determination of the limits which define a worn out hydraulic unit. There are two kinds of leakage in a hydraulic unit – "internal" leakage, from the high pressure to the low pressure ports across the valve plate, and "external" leakage from either the high or low-pressure regions, past seals and pistons, and into the case.

Both of these leakages are usually greatest at maximum pressure and maximum temperature. However, these maximum conditions cannot occur below a certain engine speed. This is the minimum engine speed that will develop the required supercharger rpm for full sea-level refrigeration, with the variable displacement hydraulic unit in its maximum pumping position. The displacement of the makeup pump at this minimum rpm (about 1250 engine rpm) determines the amount of oil that is available to supply the total "external" leakage of both hydraulic units. New units must have leakages reasonably below this upper limit.

The sum of the "internal" and "external" leakages determines the slip in the hydraulic system, which reduces the theoretical step-up ratio of the variable-speed gear box and requires a faster en-

concluded on page 66

Fig. 5 – The complete hydraulically-driven supercharger power package

More Accessibility Urged to Reduce Maintenance Costs

BASED ON PAPER* BY

T. L. PREBLE

Supervisor, Automotive Transportation, Tide Water Associated Oil Co.

ACCESSIBILITY to component parts of every vehicle should be improved whenever and wherever possible to curtail the time and cost of maintenance.

Commercial transportation, to be most effective, must be economical; maintenance is a major cost element of transportation; therefore vehicles should possess "built-in" maintenance economies. Is it not evident that the goal of commercial vehicle automotive engineering should be economy?

Vehicle producers and operators should prod themselves into an awakened realization of the fact that our Society, in its inauguration years ago of the Transportation and Maintenance Activity, recognized that the scope of engineering includes the *use* of machines, as well as the science and art of their design and production. Producers and users should be closer to one another for the common good.

Designers and manufacturers of commercial motor vehicles have created a magnificent tool for ground transportation of passengers and merchandise. This equipment has been a source of tremendous satisfaction, both in itself and in service rendered.

Within relatively few years, the express, canopy top, and stake trucks, never too well adapted to their jobs, have been replaced by package cars, tank trucks, motorized vans, and other vehicles

* Paper "Elimination of Causes of Frequent Servicing – Operator's Viewpoint," was presented at the SAE National Transportation Meeting, Chicago, April 16, 1947.

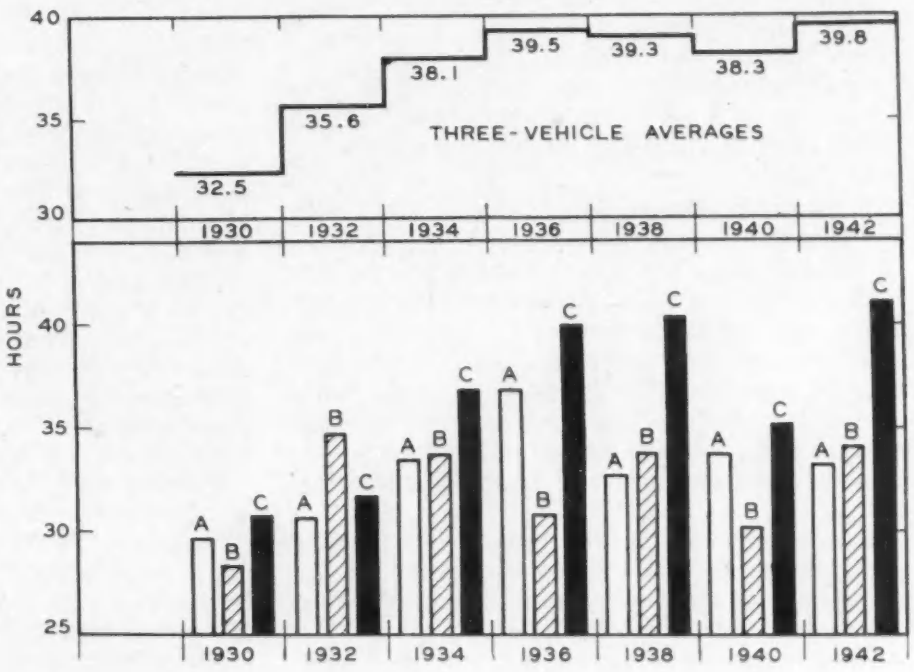


Fig. 1 – Eight-year trend in "factory time" for 10 maintenance operations on three widely-used motor vehicles

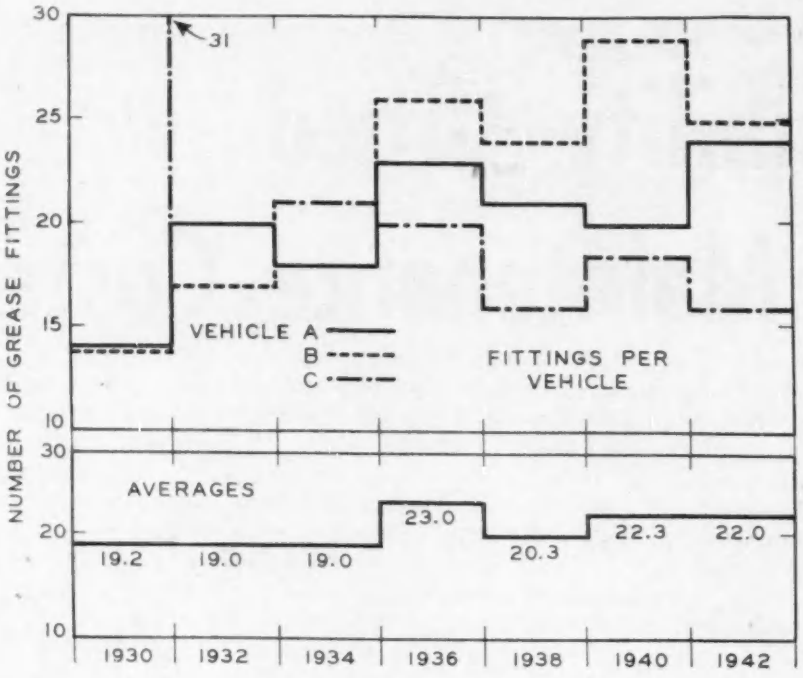


Fig. 2 – Eight-year trend in number of grease fittings per vehicle – 3 vehicles

especially designed for specific loads, operations, and services. Bodies, engines, and chassis have advanced beyond the point even of coincidental resemblance.

Appreciation widely is evident for the work and sweat and tears which wrought this amazing transformation in vehicles and made highway transportation an industry. Those who transport passengers and cargoes commercially by road can do so profitably, thanks to the men in the drafting rooms and on the assembly lines.

There is, and always has been, a mutuality of interest between those who design, produce, and operate commercial vehicles. They comprise a highway transport trilogy. Each depends upon the others, each serves the others, each benefits by the others. The chain of interdependence extends from drafting board to loading platform from assembly line to bus terminal, from sales floor to maintenance shop.

Unfortunately, changing circumstances have created difficulties which threaten to become economic road blocks to commercial highway transportation. Certain developing deterrents could impede the expansion in the purchase and use of commercial vehicles. These potent economic influences for ill must be the concern of operators. They should be the concern also of designers and manufacturers.

The major theme of this paper deals with an important aspect of maintenance. But for the record be it said that if the producer is to be fully cognizant of his obligations he will be aware that he has transportation to sell, not just vehicles.

Cost of the vehicle over its life is of paramount importance – not simply first cost. For example, first costs plus chassis maintenance costs were tabulated, covering eight years' experience on six vehicles each of makes "A" and "B," – size, mileage and operating conditions being a constant. (Accidents, tire and body maintenance and painting are being eliminated as irrelevant.) The unit first cost of "A" exceeded that of "B" by $375; total cost of "B" over the period, however, exceeded "A" by 21%.

Many producers still leave much to be desired in the tailoring of their equipment to the needs of the operator. The average operator owns but few pieces of equipment, and his lack of experience leaves him pretty much at the mercy of purveyors in the important considerations of tire size, axle loads, load distribution, selection of proper engine size, gear ratios and other aspects of "tailoring." Unfortunately many sales representatives are still woefully ignorant of these fundamentals. Certainly this ignorance is an important contributor to causes of frequent servicing.

This problem easily can be solved if only the producers' top managerial and engineering brass will take time out *personally* to get the operators' viewpoint and follow through with a concrete program for selection and training of representatives.

There is much to be desired by way of preventive maintenance recommendations (a package which should be sold with the vehicle) and, for the benefit of the producer, comprehensive tabulations of frequencies of servicing and frequencies of failure. Many fleet operators would be glad indeed to collaborate with producers in preparing such data.

The attention of designers and manufacturers respectfully is directed to the problems of maintenance and of its increasing costs. Indeed, this treatise on the elimination of causes of frequent servicing might be construed as a hard way of inviting designers and manufacturers to cooperate with fleet operations engineers in halting and redirecting this adverse economic trend.

These troubles are economic in effect but engineering in origin. They may be traced back through the assembly line to the drafting board. For this reason, operators would like to contribute from their experience, to supplement the related sciences of design and manufacture with data they have developed in practice, and to work with designers and manufacturers in removing some difficulties which harm all and do good to none.

Operators have no desire to peer over draftsmen's shoulders and to smear their drawings. Theirs is no temptation to superimpose curves on metallurgists' charts. They have no intentions of interrupting progress on production assembly lines.

Instead, it is their purpose to be helpful in any way which will lead to early solution of the problem. Operating fleets in this country now comprise approximately 1,000,000 trucks and more than 100,000 buses. Their combined operation could be regarded as the functioning of a gigantic, nationwide proving ground under close engineering and economic control. This proving ground includes all types of climates, seasons, weather, vehicles, roads, drivers, and services.

Data Are Available

Design and production engineers are invited, further, to accept these data as constituting initial reports from this proving ground. No individual, of course, properly can speak for all fleet operators. However, this speaker has conferred, consulted, and swapped yarns with so many fleet operators and their engineers for such a long period and over such a wide geographical area that the information herein presented may be regarded as something more than idle rumor, more substantial than personal opinion.

Present word from this proving ground of commercial vehicle operations is that the cost of vehicle maintenance has risen to the point which makes reduction mandatory. Fleet operations engineers have studied and still are studying various methods of solving the problem, such as extending periods between shop visits and overhauls.

It is difficult to escape the conclusion that further maintenance economies must be designed and built into commercial vehicles at the factory. In other words, maintenance economies no longer can be classified, or sold, as "extra equipment."

Proving ground experience suggests two possible correctives:

First, vehicles can be designed and built so that they require maintenance operations less frequently, and

Second, vehicles may be designed and built so that these necessary maintenance operations consume less shop time.

Through the years, design and manufacture have advanced tremendously and have made routine maintenance operations far less frequent. Results include the extension of productive running-time, curtailment of expensive down-time. This achievement has made financially possible no little highway transportation service which otherwise never could be more than a marginal operation.

Labor Productivity Down

The second suggestion, however, is complicated by peculiar and discouraging circumstances. In January, 1946, a spokesman for the automobile industry declared, in the New York Times, that, compared with prewar standards, labor productivity is off 25% for the same work with the same tools. It is reasonable to suppose that those who maintain vehicles are less productive in the same proportion as those who build them. It can, therefore, be presumed that maintenance operations now consume more time than before the war.

Information from manufacturing centers reports substantial increases in manufacturing costs. These same changed circumstances apply to maintenance. Maintenance mechanics received 80¢ per hr in 1930; they now receive $1.40. In other words, the prime cost of shop labor has advanced to 175 as contrasted with 100 in 1930. Taking into consideration the 25% loss in productivity, this advance really is in the proportion of 233%.

The basic policy of designing and building commercial motor vehicles for operation rather than maintenance has become a boomerang. The better the vehicle, the more sensitive it is to adjustment, and the more difficult the adjustments. The better the vehicle, the more difficult and extended the maintenance operations. And the fewer the routine maintenance operations, the longer and more costly they appear to be.

Those disinclined to accept these statements may find substantiation in time studies. Take the case of 10 routine maintenance operations, essential to every vehicle regardless of make or model. Fig. 1 shows an eight-year trend in down-time for these operations as measured by factory time estimates for three different widely-used vehicles. It will be noticed that there is an irregular but persistent upward trend in the number of hours which must be devoted to this necessary maintenance work.

The upper portion of this chart shows the averages for the three vehicles. In each case the number of hours has been increased 10% over factory estimated time. This increase represents a reasonable allowance for reduced productivity.

This chart of averages is especially interesting because it discloses the results of the general trend. Average maintenance time for the average vehicle is 39.8 hr in 1942 as against 32.5 hr in 1930. The labor cost in 1930 at 80¢ per hr was $26.00. The labor cost in 1942 at $1.40 per hr was $55.72. In 1930 two cars were given routine maintenance jobs for less than the cost of one job in 1942.

Maintenance Costs More

These data cover time and labor costs alone. They do not take into consideration the increased cost of parts. They do not incorporate the substantial expenses of down-time, whether in loss of productivity or rental for replacement vehicles. These costs in themselves have risen proportionately. And however great the disagreement with these figures, the trend is inescapable. Maintenance takes longer and costs more.

Anyone inclined to believe that the situation improves with postwar vehicles may face sad disillusionment. So far as can be ascertained, the trend is sharply upward. One passenger car, for instance, is designed and built so that the engine must be lifted from the chassis in order to remove the oil pan. Another has rear fenders welded in place. In case of fender replacement, body panels must be removed. These developments, whether they apply to trucks, buses, or passenger cars, are matters for serious concern. They involve folding money – and they are design factors of no inconsiderable pertinency. The fact that maintenance operations may be necessary only one-half as frequently is scarcely an excuse for making them more than twice as expensive.

Some maintenance operations are, of course, rather infrequent. However, this is not the case with lubrication, which is undertaken both frequently and regularly. Designers and manufacturers know that lubrication is necessary. They know how it is done. And it is not, ordinarily, a complicated operation.

Fig. 2 pictures the eight-year trend in the number of grease fittings per vehicle – calculated from the same three popular vehicles. Vehicle A started with 14 and progressed to 24. Vehicle B started with 14 and reached a peak of 29. Vehicle C was a maverick. It started with 31 and got down to 17.

The trend, however, is shown by the averages – an upsweep to 23 from 19. Actually, the trend is worse than can be shown here. This chart cannot evaluate the factor of accessibility. Here again there can be serious increases in maintenance costs, and it is not unreasonable to suppose that doubling the number of grease fittings could triple lubricating time.

Accessibility Paramount

Accessibility is a tremendously important factor. It affects also the willingness to maintain, a morale factor particularly pertinent in these grim days of labor unrest. Designers and manufacturers can be concerned here, for sales of their product, their very reputation, can hinge on how well their vehicles serve.

Fleet operations engineers, inspectors, and mechanics take off their hats to the men who design and build the new vehicles. But they speak in purple language, which need not be repeated here, of the diabolical ingenuity which seems to them to have been directed to making maintenance operations as difficult and as discouraging as possible.

It is unnecessary here to catalog the inaccessible parts, and inspection points, and adjustment points of the commercial vehicle. Designers and manufacturers must know them pretty well. In-

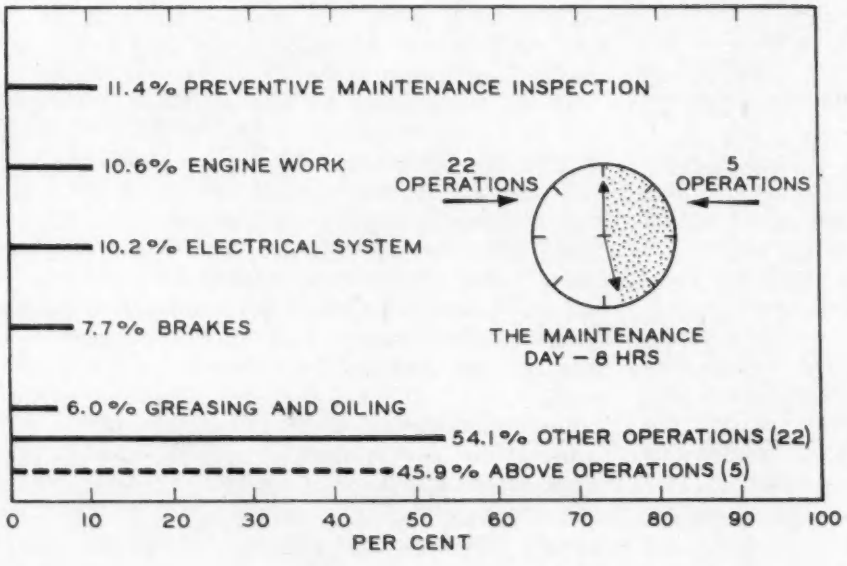


Fig. 3 – Five operations, delayed by inaccessibility, require nearly one-half of maintenance time

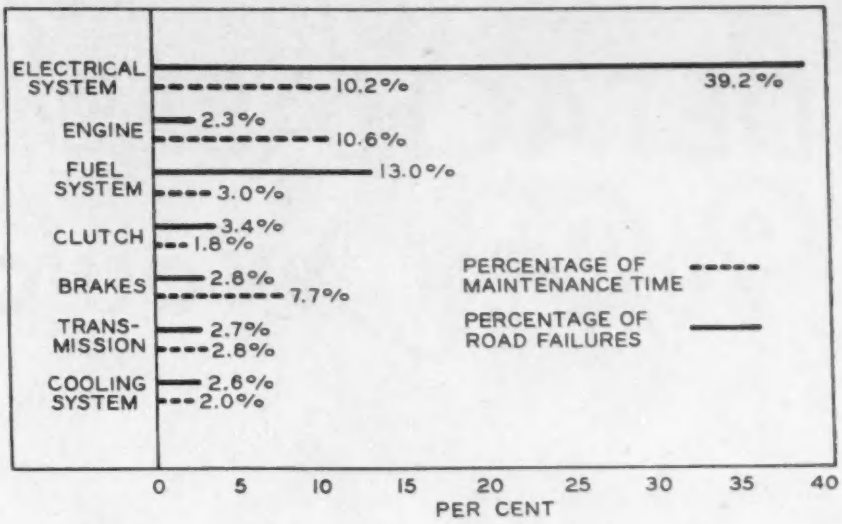


Fig. 4 – Comparison of percentages of maintenance time and of road failures

deed, they have special factory equipment, seldom available to operators, for easily accomplishing feats which, in the shop, demand special tools, considerable time, and mechanics who combine the talents of contortionist, acrobat, magician, detective, and saint.

Those who may wish to delve more deeply into the matter – and delving is only the beginning – respectfully are referred to the comprehensive compilations of maintenance difficulties outlined in the SAE papers, "How Changes in Models Affect Automotive Maintenance," by Ellis W. Templin; "What Do Fleet Operators Want in Postwar Trucks?," by Gavin W. Laurie; and "Truck Design from the Standpoint of the Operator Engaged in Local Trucking and Delivery Service," by Willard D. Bixby, Ralph M. Werner, and Harvey H. Earl. These are readily available from SAE Special Publications, and could be provocative reading for any designer or manufacturer.

Routine Analyzed

A few points from the Bixby-Werner-Earl paper are pertinent here. Fig. 3 is based upon those data showing the time consumed in performing five routine maintenance operations. These data are taken from records covering 1000 driver days and a full year of operation.

Notice that 11.4% of maintenance time is devoted to preventive maintenance inspection. The engine and the electrical system each required more than 10% of maintenance time, while brake maintenance and greasing and oiling operations take slightly less. These are, however, only five of the more frequent of 22 routine maintenance operations, yet these five alone consume 43.5% of maintenance time. In other words, nearly one-half of the maintenance day must be devoted to inspection, the engine, the electrical system, the brakes, and lubrication.

This paper presents another interesting point. Maintenance of the electrical system requires 10.2% of maintenance time – the third largest investment, notice. Yet the Bixby-Werner-Earl analysis of road failures, based on four and one-half million service miles, shows that electrical system failures lead all the rest – 39.2% or 712 from a total of 1645 failures. This analysis further shows that the engine, electrical system, and brakes, to which 28.5%, or better than one-quarter of maintenance time is applied, cause 44.3%, or nearly one-half, of all road failures. The conclusion could be reached, without tortuous reasoning, that maintenance time is poorly divided, maintenance operations are something less than fully effective, or there is some barrier to doing a thorough job of preventive maintenance.

Fig. 4 tells the story visually. From this chart one might gain the impression – which has not exactly been hidden under a bushel these last few years – that vehicle electrical systems do not react well to maintenance, and that troubles in this field must be corrected by improving the electrical system. Progress in engine design, in this respect, is clearly evident. Application of slightly more than 10% of maintenance time appears to hold engine road failures to a small proportion. The same is true of clutch, brakes, transmission, and cooling system. The fuel system appears to join the electrical system in resisting maintenance.

Engineering attention should be directed to improving the electrical and fuel systems, and other parts which do not now respond properly to maintenance, that they may serve equally as well as engines, brakes, and other heavy working parts already do.

Something should be done to shorten the time required for the maintenance operation of lubricating; 6% of maintenance time seems much too long.

An SAE committee might be created to undertake the basic job of coordinating needs, ideas, and possibilities of (a) increasing accessibility and (b) curtailing maintenance time and cost.

DETACHABLE ENGINE Would Simplify

BASED ON A PAPER* BY

E. H. ROWLEY

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EXPERIMENTAL work is being done on developing a detachable powerplant, such as an outboard engine for boats, to take the "muscle" out of the sport of gliding.

Nelson's successful "Dragon Fly" is a glider with an integral powerplant, whereas this conception is a power package that could be readily attached to existing sail planes.

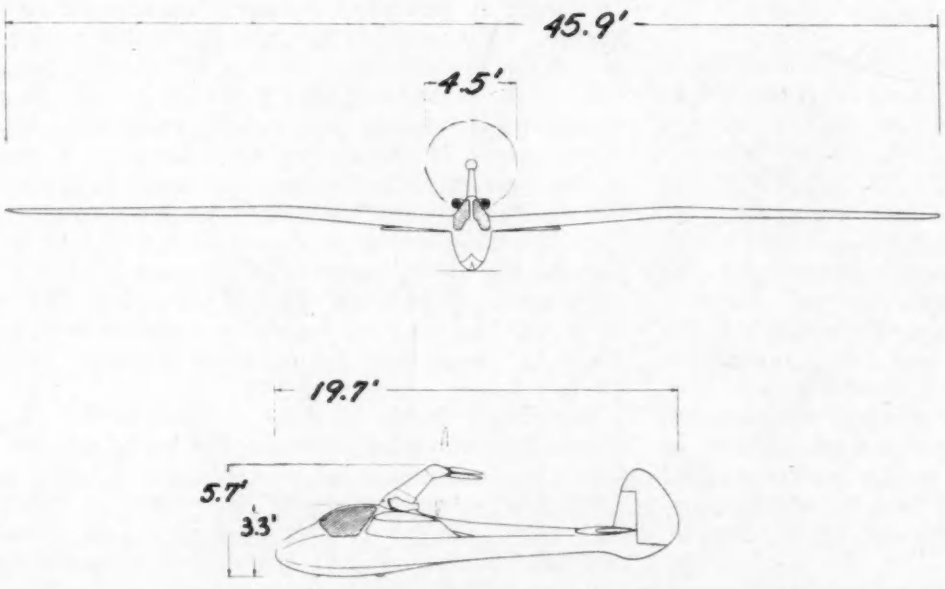
Because the design of an optimum engine layout is not available, a direct opposed, four-cycle, 3 3/16 bore x 2¾ stroke, 6.8 to 1 compression ratio engine was chosen. The propeller reduction was 2 to one.

Having decided to carry out the size angle to the practicable limit, an L-head design was chosen, thus cutting the engine width and weight to a minimum. This engine layout was believed to be superior particularly when considering future possibilities of buried engine installations.

In view of possible buried installations, and the experimental being a "pusher," it was decided to completely cowl the cylinders and use individual jet pumps. Provisions were also made in the design for a centrifugal blower to be mounted on the fly-wheel, if the jet pump did not prove satisfactory. The fly-wheel is necessary, because the propeller is collapsible. Therefore, for starting, a fly-wheel is mandatory. This engine is purported to produce 22 hp at 45 rpm, and weighs 45 lb, dry.

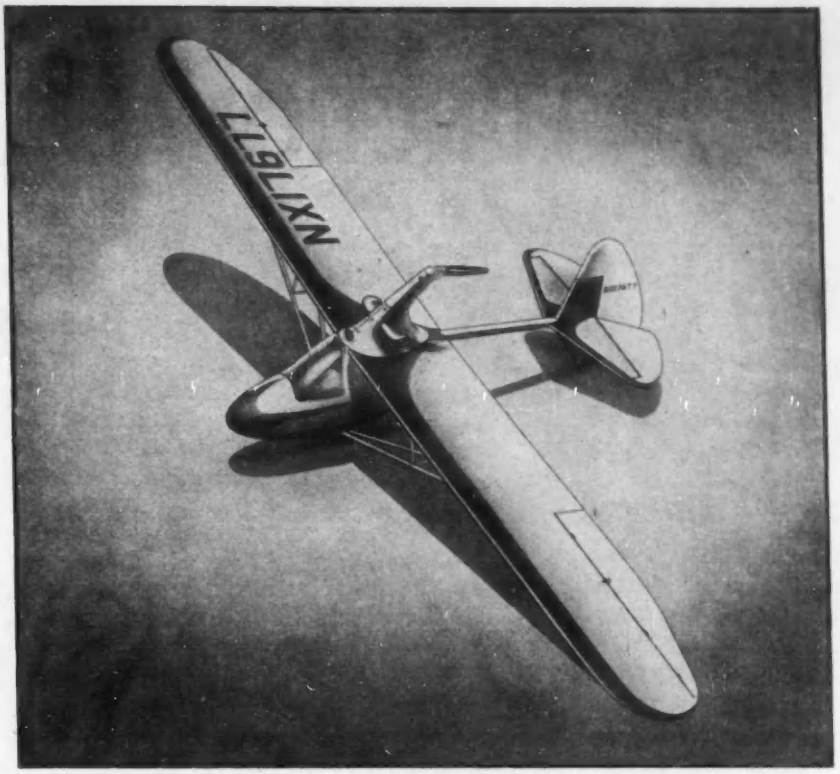
Several propeller ideas were thoroughly investigated, such as a clutch to disengage a fixed pitch propeller from the engine, thereby allowing

*Paper "Design for Power Soaring," was presented at the SAE National Personal Aircraft Meeting, Wichita, Kans., on May 2, 1947.



General arrangement of a sailplane and an outboard pusher propulsion unit.

fy Gliding



The Rowley utility glider equipped with folding propeller

the propeller to windmill while the engine was stopped in flight. However, the weight and complexity were considered to be as great as a folding propeller.

A two-bladed automatic folding propeller, consisting of conventional wood blades and a steel hub, which houses the folding mechanism, slam-dampening cylinder, was decided upon. Designing this propeller was difficult after it was found that the critical conditions of operation occurred during the latter portion of the unfolding process.

In unfolding, dampening that motion could not take place until late in the process, thus lessening blade bending due to high centrifugal forces imparted during the first 45 deg of travel. Also a definite advantage appeared when it was decided that the installation was to be of a "pusher" type, in that the folding process, when the engine was stopped became simple because the air loads assisted in minimizing the energy required to fold the propeller. During starts and warm-ups in the air, the propeller will remain folded until a propeller shaft reaches 1000 rpm.

When the propeller design was completed the 54 in. unit weighed only 7½ lb, which did not appear critical, and the advantage of zero prop drag was gained.

The pedestal between the engine and the gear reduction unit is monocoque, fabricated from sheet dural, with provisions made for the gas tank inside. This is then mounted rigidly to the engine crankcase on the lower end, and the gear box mounted on the top end.

The engine is then mounted on a small tubular structure which has shock mounts at the point where the tube structure mounts to the airplane structure. A drive shaft with a torsional dampener connects the engine to the gear box. The cowling around the engine is so designed that it may be removed readily and contains the necessary firewall to separate the engine from the airplane structure. Upon removal of the cowling and fillet combination, the engine is completely bared, and the four attachment pins are accessible.

The only connection to the airplane would be throttle and starter cable, which are easily disconnected or connected. The whole installation, less the fillet and cowling, would comprise a single unit easily handled by one person. The fuel tank is built into the monocoque structure, fuel connections to the airplane are unnecessary.

With weight of engine, fuel, and oil totaling 80 lb, the following compares a test glider with and without the detachable powerplant:

	Without Engine	With Engine
Normal Gross Weight	530 lb	160 lb
Wing Loading	3.18 lb per sq ft	3.59 lb per sq ft
Minimum Sink	2.8 ft per sec	3.2 ft per sec
Gliding Ratio	19 to 1	18 to 1
Stalling Speed	28 mph	32 mph

FUNCTIONAL ARRANGEMENT Ur

Aircraf Co

WE have developed certain basic principles of cockpit design. Many of these principles had been violated for years, and as a result, many pilots lost their lives.

Basic Principles

The most basic principles of cockpit design are (see Figs. 1-3):

(a) Transfer of Control – The pilot should not be required to transfer control of the aircraft from one hand to the other during take-off or landing. This principle was violated for years. For example, landing gear, flap, and canopy controls were located on the right side of the cockpit, which meant that immediately after take-off the pilot was required to remove his left hand from the throttle, transfer it to the stick, and fly left handed while he operated his wheels, flaps, or canopy controls. Just how many crashes this masterful piece of design caused we'll never know.

(b) Transfer of Vision – In many aircraft it was necessary for the pilot to look in the cockpit to find a landing gear or flap control. This meant that at a critical period he took his eyes from outside the aircraft and focused them into some recess of the cockpit.

(c) Controls Forward for Take-off – For years there was no rhyme or reason for the way many important controls operated. For example, our prop control was mounted on the aft end of the power control quadrant and moved up and down rather than fore and aft, as did the throttle. The mixture control was another offender. Some installations actually had the idle cutoff position at the forward end of the quadrant, just beyond the full-rich or take-off position. In other words, if you pushed all controls forward for take-off you could cut off the fuel. Supercharger controls fell in the same category. Often the low blower – or take-off-position – was at the aft end of the quadrant rather than at the forward end. To place all controls forward for take-off could cause loss of power and a crash. There were many other controls in the same category.

We concluded that certain controls should operate fore and aft and that they should be forward for take-off, making it simple for the pilot and almost foolproof.

We applied this principle to almost all controls, including switches in the cockpit.

(d) Motion and Travel of Control to Correspond to Motion and Travel of Equipment it Operates – This principle would seem to conflict with the forward-for-take-off principle. When it does we apply the principle that seems to make the most sense. For example, we have the landing gear lever operate in a vertical plane – up for wheels up and down for wheels down. Flaps are in a

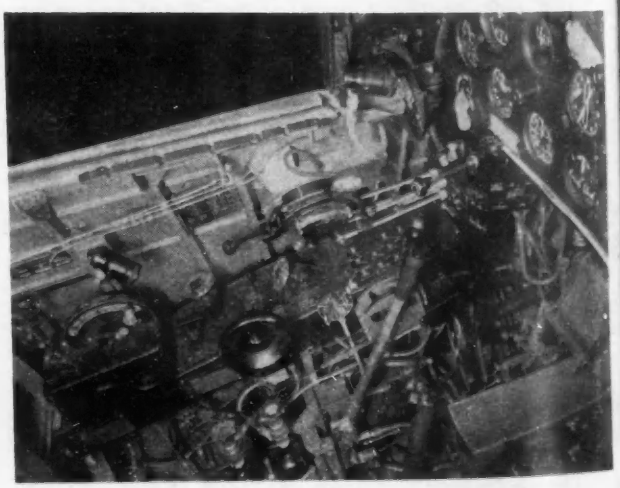


Fig. 1 – Left view of Navy fighter cockpit at beginning of war – note scattering of flight controls and confusing picture presented to pilot

* Paper "Development of Functional Cockpits for Naval Aircraft" was presented at the SAE National Aeronautic Meeting, New York City, April 11, 1947.

NT Urged for af Cockpit Design

EXCERPTS FROM A PAPER* BY

Com. Norval R. Richardson, USN

Cockpit Development Coordinator,
Research and Development Group,
Navy Bureau of Aeronautics

similar category – up for flaps up and down for flaps down.

(e) Separation of Controls – In many aircraft the flap and landing gear controls were in the same area and often side by side. Just how many crashes this caused we'll never know. The possibility of this type of accident can be practically eliminated by separating these controls and locating them in their logical and functional location. We now locate them in different areas of the cockpit where they will be operated in a logical sequence along with the powerplant and other controls.

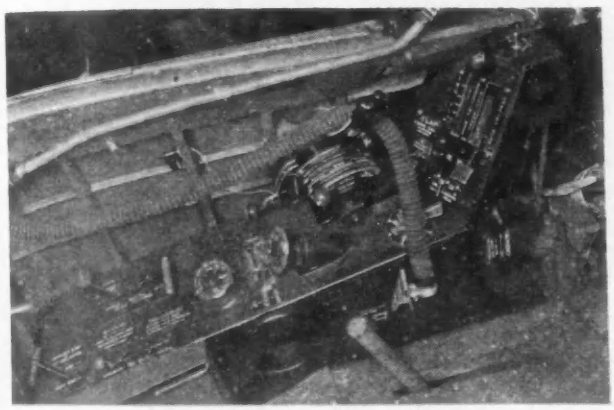


Fig. 2 – Left view of same cockpit shown in Fig. 1, showing considerable progress achieved in first attempt at cleanup – note that controls are differentiated in location, shape, size, and orientation to eliminate transfer of vision

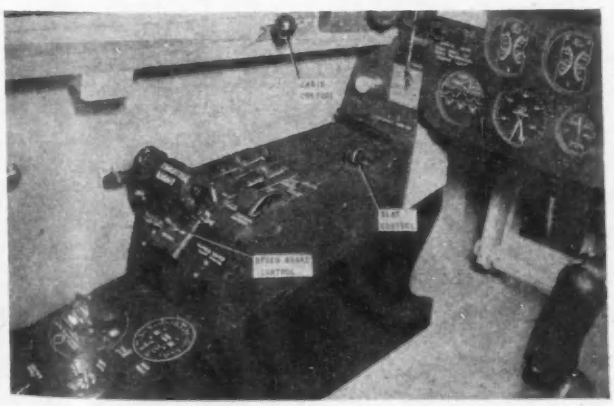


Fig. 3 – Left view of mockup of late Navy fighter cockpit, showing how limitations of space were overcome by good engineering – note streamlining, elimination of crash and injury hazards

(f) Combination of Controls – In many aircraft the emergency or auxiliary controls would be buried in remote recesses of the cockpit where a pilot couldn't possibly find them in an emergency. We now try to combine the normal and emergency control in one – or at least have them adjacent, where the pilot can find them and understand how to operate them with a minimum of time and effort.

(g) Economy of Motion – In many cockpits there was no thought given to the location of controls that must be operated in sequence – like the cockpits in which it was necessary to change hands on the control stick to retract the landing gear, flap, and close the canopy. We now have an arrangement that is logical, efficient, simple, and almost foolproof. For example, we take off with our left hand on the throttle and our right hand on the stick. Immediately after take-off we move our hand just forward of the throttle and flick up a switch to raise the landing gear, then we move our hand aft to a point directly above the throttle and flick another switch aft to close the canopy to reduce the drag still further and to make the cockpit more livable. Then we drop our hand to the aft face of the power quadrant and dump the flaps as fast as the aircraft attains sufficient lift. At no time is it necessary for the pilot to see what he is doing nor is it necessary for him to move his hand far from the all-important throttle.

(h) Economy of Time – Controls must require a minimum of time and effort on the part of the

pilot. We resolved this principle in three ways: First, we substituted power-actuated devices for manual. Next, we required that the pilot only take the time necessary to flick a control or switch rather than hold it during the cycle of operation. Last, wherever possible we make the control automatic with an override control feature.

(i) Functional Arrangement of Controls – Cockpit controls were being installed not where they should be from the pilot's or the functional viewpoint but where it was possible physically to locate them. By making most of them remote operating we were able to make them small and locate each one where it should be from the functional viewpoint.

(j) Limitations of Space – The addition of so many controls and gadgets placed severe restrictions on the space available in the cockpit. We had one relatively fixed variable – the pilot. We knew that he could be only so big – or so small – and that he could not be changed. It was imperative, therefore, that we reduce the size of the controls if they were to be incorporated in the cockpit and brought within reach of the pilot. This was done, as I've noted, by making them remote controls.

(k) Streamlining – The first step in fairing in equipment was in the development of radio and electrical consoles. Shortly thereafter we applied the same console treatment to the left side of the cockpit, neatly fairing in all powerplant and trim tab controls. We also installed decks as standard equipment. The results were surprising. Despite the addition of many controls the cleaned-up versions looked simpler and were easier to operate.

(l) Crash and Injury Hazards – We are still striving to get all equipment cleaned up and recessed. All sharp objects have been removed or faired in so they will not cause injury. More attention is being given to body clearances, head, knees, and elbows.

Seating

There were still, however, too many variations in cockpit sizes and relative spacing of various controls. By using the dimensions recommended in the Army report, "Principles of Seating in Fighter-Type Aircraft," prepared under the direction of Capt. Francis E. Randall, as a basis, we could evaluate a cockpit design and know with some certainty that cockpits would accommodate pilots over a wide range of size.

Pilot Escape

As aircraft increased in speed new problems developed in cockpit design. In high-speed aircraft it is almost impossible for a pilot to get out of his aircraft without being thrown against some part of the structure. Ejection seats were developed, which catapulted the pilot clear of the aircraft where he can, when he has slowed down, safely use his parachute. This method has been safely demonstrated by the Germans, British, and the U. S. Army and Navy, but it has only been used on an experimental basis in this country.

The installation of ejection seats introduced a host of new problems. We must, of course, provide adequate clearance for the pilot and his seat during ejection. We must also retain our functional arrangement so that all controls are accessible for the full range of pilot sizes.

The seat ejection method must be considered as merely a step in the development of escape from high-speed aircraft. The next step will probably be an ejection cockpit or capsule. The reasons are obvious. First, we may be flying at supersonic speeds and in the stratosphere. Pilots would very likely be torn apart if they were ejected at supersonic speeds – and if they weren't they would die from lack of oxygen. If that didn't finish them off they would freeze to death before they reached the earth. Pressurized cabins might be equipped to serve as life rafts for landings on the water or as warm shelters for landings in the Arctic wastes.

Ejection cockpits for crew members are still in the study and discussion stage, although we do have a simple type installed in one of our experimental high-speed aircraft. The development of ejection cockpits may mean that we will have to start all over and redesign every cockpit component.

Prone Position

Prone-position cockpits have been built on an experimental basis for many years. We still have no fixed opinions as to their desirability. They apparently solve certain problems but create many more. We must know much more about human limitations under high negative and positive accelerations before we know whether prone cockpits are desirable.

Comfort

We know that pilots must be comfortable if they are to be effective and safe. In one of our recent fighters we had a number of crashes attributed to pilot fatigue caused by an uncomfortable seat. We are now being faced with other problems in high-speed aircraft. Cockpit temperatures climb precipitously, so that it is necessary to install air-cooling systems. Cockpit noise was serious with our prop-driven reciprocating engines. We still don't know enough about the jet types to know if noise or vibration will be a problem. Some of them have been unusually quiet and free from vibration. Whether we can expect that to continue we still don't know, as we expect to use propjet combinations for certain aircraft.

BASED ON A PAPER* BY **D. S. KING**
Lycoming Division, Aviation Corp

CURRENT trends in the light aircraft field indicate the following developments will be applied to low-horsepower engines in the near future:

- Non-icing fuel metering equipment.
- Exhaust mufflers, modified controllable propellers, geared engines, and maybe eventually multiblade controllable propellers to reduce airplane noise level.
- Supercharging in engines of 300 hp and over.

Fuel Metering

Fuel injection or some other effective non-icing type of fuel metering will probably be more widely used on all sizes of light aircraft powerplants. Considerable work has already been done along this line, but progress is slow, expensive, and at times disheartening. Some progress is being made, however, and improvements can be anticipated eventually.

Noise Reduction

The main sources of objectionable noises are the engine exhaust and the propeller.

A start has already been made in eliminating the first noisemaker in some small aircraft by the use of exhaust mufflers. Much work still remains to be done, nevertheless, for the problem is not as simple as it seems.

Considerable juggling of pipe sizes, lengths, carburetor settings, and the like, is necessary to keep power losses in the exhaust system to a minimum.

Previous work with jet exhausts and manifolding in tests conducted on large radial engines indicates that exhaust manifolding losses are minimized or eliminated when the exhaust pipe arrangement does not permit a single pipe to carry exhaust gases from two or more cylinders whose exhaust strokes overlap. This same principle applies to the exhaust manifold problem in light engines. Apparently a pressure wave is carried through the exhaust system, which adversely affects the output of either or both cylinders when these exhaust impulses overlap.

An experimental exhaust system was designed based on this principle. As shown in Fig. 1, a conventional 4-cyl engine with a firing order of 1-3-2-4 was designed to give a 360-deg spacing of the exhaust charges carried by any single pipe or manifold. An exhaust system was finally produced – with the same muffler used in the original installation – that gave power output comparable to – and at some points better than – that previously obtained with open exhaust stacks, as shown in Fig. 2. Advantages of the cross-over design are admittedly greater at the higher engine speeds and fuel flows shown, but for the range tested this manifold ar-

* Paper "Engines for Light Aircraft" was presented at the SAE National Personal Aircraft Meeting, Wichita, Kans., May 1, 1947

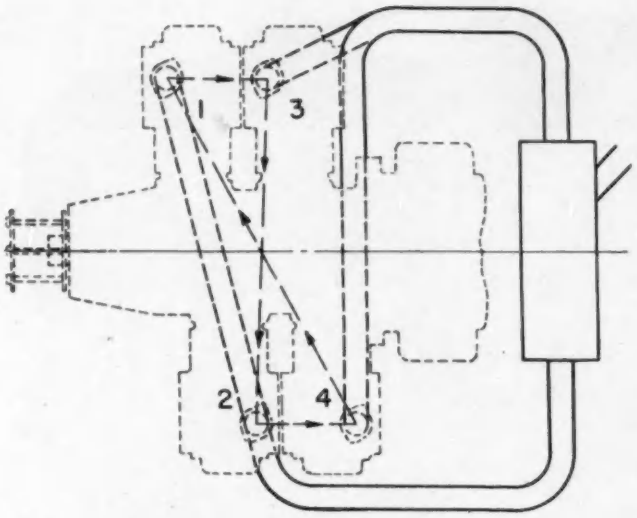


Fig. 1 – Cross-over exhaust system arrangement for conventional 4-cyl engine – firing order: 1-3-2-4

rangement with a muffler consistently produced at least as much power (with smaller exhaust pipes than those previously used) as a short exhaust stack arrangement and no muffler. While such an arrangement of exhaust system does not lend itself as readily to airplane installations as do the more conventional arrangements, it does indicate what can be done. To eliminate, or at least minimize these power losses, however, the design of the exhaust system using a muffler must be closely coordinated between the airplane and the engine manufacturer. Extensive tests of engine and exhaust system under simulated flight conditions will permit accurate evaluation, which can pay off in increased airplane performance.

Although exhaust muffling is a definite step in the direction of reducing noise, actually the principal source of the trouble is the propeller. More extensive use of controllable propellers at higher take-off speeds further aggravates the noise problem, particularly as power outputs and speeds increase. The latest approach to the problem involves the use of slower-turning multiblade propellers. While the multiblade propeller problem is out of the hands of the engine manufacturers, the problem of putting the same power into a slower-turning propeller seems to indicate the geared engine as the logical ultimate powerplant, especially in the higher-horsepower range.

In the lower-power classes, the 4-cyl direct-drive engine is admittedly the most economical solution, but cylinder sizes and engine roughness would be too great if, say, 175 hp were attempted at normal propeller speeds with a direct-drive engine. A 6-cyl direct-drive engine operated at comparatively low speeds is one solution, but perhaps not the best one, especially if propeller speeds as low as 1400 rpm, for example, come into the picture. A change in speed at the same power is relatively simple on a geared engine, as compared with the direct-drive design. With the two additional cylinders, longer and heavier engines and additional installation requirements for exhaust systems, and so on, could be expected, as compared with what would be necessary for a geared 4-cyl engine using the same cylinder design. Fig. 3 shows the outline of a geared 4-cyl engine superimposed on that of a direct-drive 6-cyl engine of the same bore and stroke. Displacements of the two engines are 290 and 435 cu in., respectively.

As shown in Fig. 4, the 4-cyl geared engine delivers 160 hp at 1925 rpm (3000 crankshaft) and 175 hp at 2180 propeller rpm (3400 crankshaft) for take-off. The 6-cyl direct-drive engine, while it will deliver 190 hp at 2550 rpm, will only deliver 135 hp at 1925 rpm, and 160 hp at 2180 rpm. The geared 4-cyl engine is 17 lb lighter than the direct-drive 6, even though the oversized planetary-type reduction gear used is adequate for 6- and 8-cyl engines at more than 350 hp. Further weight savings could certainly be made in a production version at no decrease in performance or dependability.

The increased propeller efficiency possible at the lower speeds with the geared engines should be a factor in overall airplane performance. While the lower propeller speed with the geared engine requires a larger propeller diameter, there is some apparent improvement in overall airplane noise.

Development of geared engines has indicated that they also have their problems. Addition of the reduction gear results in torsional amplitudes considerably greater than those encountered with the direct-drive crankshaft before addition of the

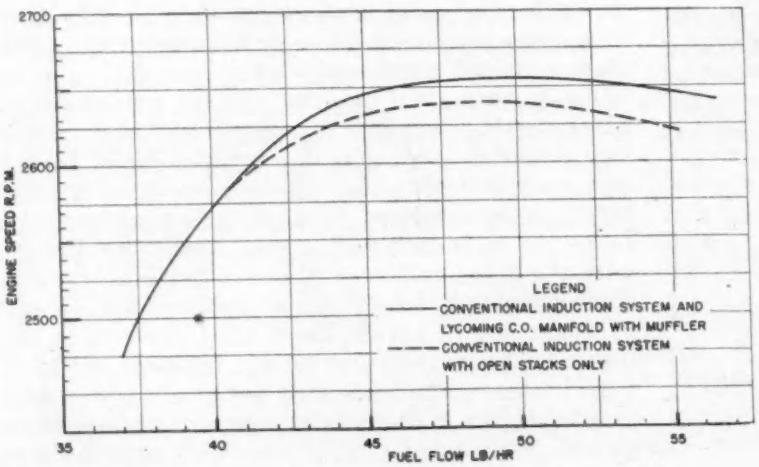


Fig. 2 – Comparison of engine performance with conventional (open stack) and cross-over exhaust systems

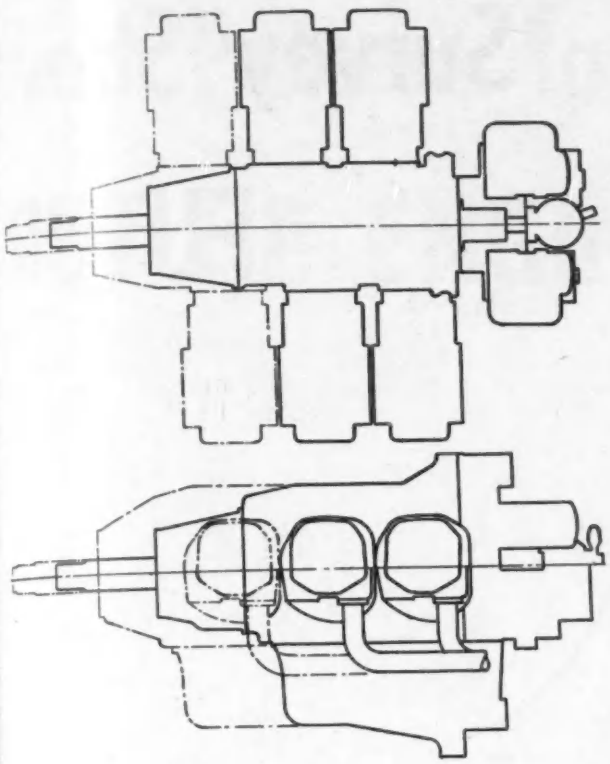


Fig. 3 – Outline comparison of geared 4-cyl and direct-drive 6-cyl engines

reduction gear. To overcome this condition, it is necessary to add pendulum-type vibration dampers. On the 4-cyl geared engine four second-order dampers and three fourth-order dampers are used. The 6-cyl engine uses a total of six dampers and the 8-cyl uses eight. Extreme accuracy must be used in fabricating these dampers in regard to weight, location of center of gravity, and quality of workmanship, but results obtained seem to justify the care taken in providing this amount and type of torsional damping.

As with many new applications of old ideas, there is some resistance to the idea of gearing small aircraft engines, even though it is accepted practice with the larger powerplants. It is felt that as more persons come into contact with geared engine performance, general acceptance will follow rapidly.

Supercharging

As engine sizes reach the class of 300 hp and over, their applications to larger airplanes with higher performance requirements indicate that supercharging should be used to obtain take-off and altitude ratings. Any advantages to be gained by supercharging lower-powered engines would not seem to offset the increase in weight and cost where altitude ratings are of secondary importance and adequate take-off ratings can be obtained by increasing rpm with controllable propellers. With the larger engines and correspondingly larger propeller diameters an increase in propeller speed for take-off power produces mostly noise for the added effort. With supercharging the increased power required for take-off can be obtained at no increase in propeller speed and adequate power can be maintained for operation at altitude. Airplanes using these larger powerplants are definitely of the cross-country type and have such wide application that they must necessarily maintain power at altitude. While requirements may vary it seems that a supercharged engine in this power class should be capable of maintaining sea-level normal rated power to an altitude of 7000 ft. It is assumed that controllable propellers would be considered as standard equipment on installations using such a powerplant.

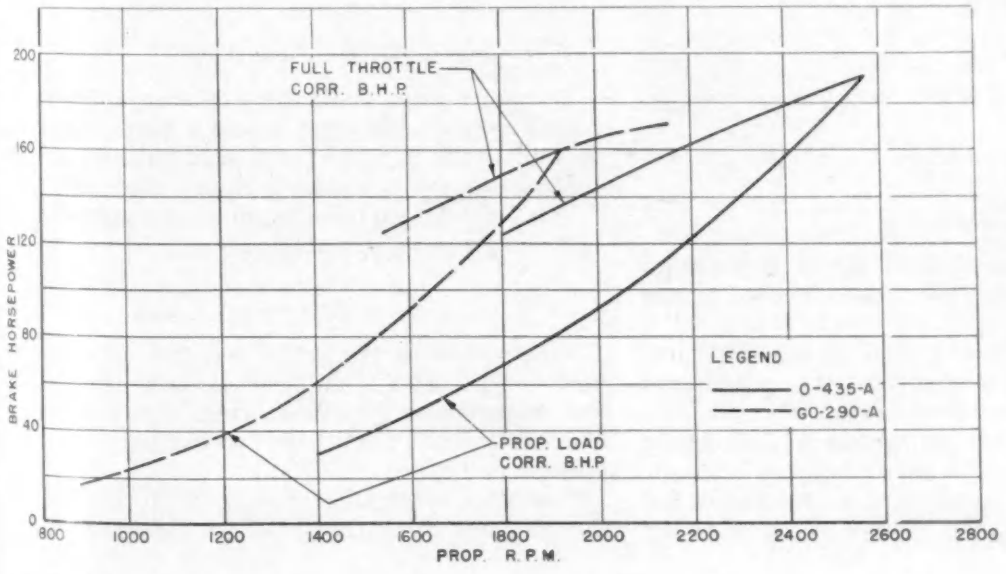


Fig. 4 – Performance comparison of geared 4-cyl and direct-drive 6-cyl engines
O-435-A: Direct-drive 6-cyl engine
GO-290-A: Geared 4-cyl engine

Survey Shows C
FUTURE L

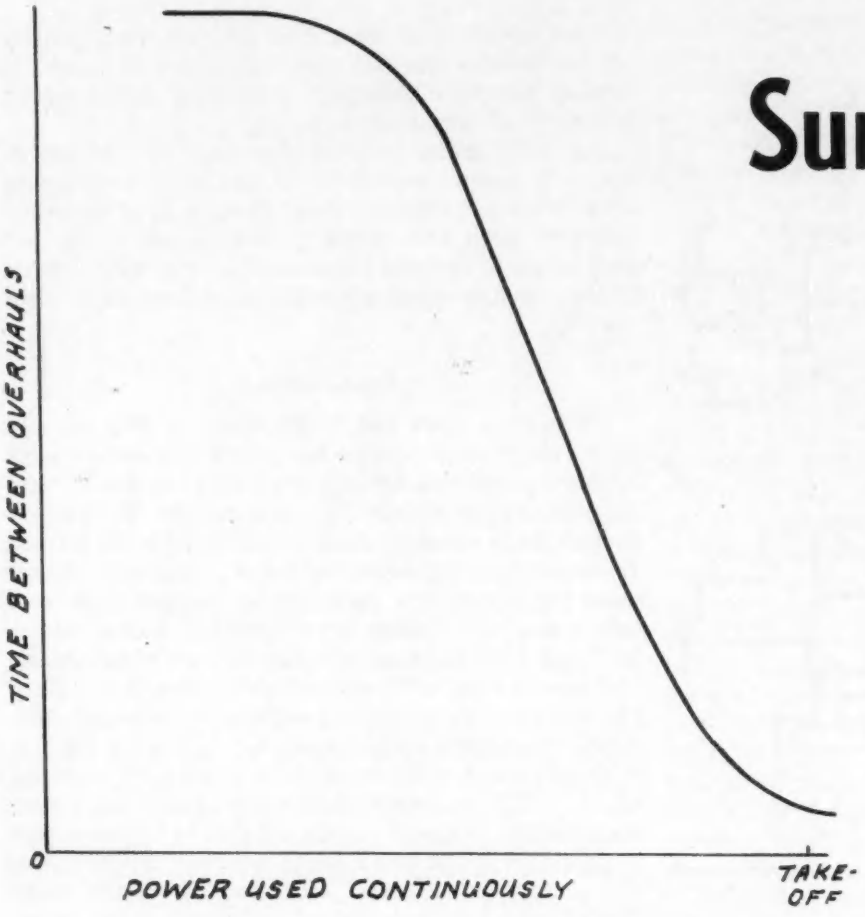


Fig. 1 – Effect of continuous power on durability

THE low-horsepower engine of the next few years is already rapidly taking shape in the minds – and laboratories – of engine manufacturers and airplane operators, according to a survey made last summer for Continental Motors Corp.

This survey was made to find out what modifications low-horsepower engine manufacturers and personal airplane operators think are needed in existing powerplants and the new types that they feel should be developed to meet future requirements.

The main topics covered by the survey are discussed here.

Power Range

For the 2-place plane, 80-90 hp at a propeller speed of not more than 2300 rpm is favored by the majority.

There is little interest in the 3-place airplane, but much thought is being given to the production of a 4-place ship of moderate price. For this aircraft the majority want an engine of 140 hp or over (some estimates even go as high as 230 hp), indicating a strong trend toward higher power for this class, as most of the 4-place ships of today are powered by 150 hp maximum. The majority favor speeds of not more than 2300 rpm.

For a 4-5-place deluxe ship, 220-250 hp is favored. It is felt that speed should be kept at 2300 rpm maximum, even in this class, in the interests of best efficiency and low noise level.

General Arrangement

For the 2-place plane the 4-cyl flat, opposed, air-cooled engine is favored unless a 6-cyl engine can be built with a weight and cost penalty not exceeding the 4-cyl figures by more than 10%.

The 6-cyl flat, opposed engine is considered to be best for the 4-5-place ships.

Accessories

All manufacturers prefer starters of the automotive type, with a simple foot control for the direct engagement type of starter. This reduces the effort to operate the starter, as compared with the present pull type.

The 12-v system is acceptable at present, although some think that the 24-v system should be

Clear Pattern for LOW HP ENGINES

BASED ON A PAPER* BY **Peter Altman**
CONSULTING ENGINEER

considered for the 4-5-place planes, provided it can be obtained at the same cost as the 12-v system.

The majority of the representatives voted for the builtin drive for generators and for at least 15 amp for the 2-place and 20 amp for the 4-5-place airplanes.

Battery ignition is acceptable if good altitude characteristics are coupled with a reduction in cost and weight, as compared with the magneto system, and a secondary source of electrical energy is available.

Although manufacturers are opposed to the use of superchargers in small airplanes, it was indicated that for the deluxe 4-5-place ships, provision for supercharging would be desirable. Then it could be installed for the operators wanting it.

The majority indicated that controllable-pitch propeller designs are not sufficiently fixed to provide definite features in the engine design to accommodate this type of propeller. Consequently, propellers should be designed to fit standard engines with the least number of modifications.

The flange crankshaft end is held to be most acceptable for small airplanes with fixed-pitch propellers, while the spline type is favored for the 4-5-place aircraft, to give interchangeability between controllable- and fixed-pitch propellers.

All manufacturers favor a standardization program to provide interchangeability of propellers and related items for different engines.

General Design Features

Gearing is considered acceptable only if the cost is less than for the direct drive of the same power, and the gear unit is quiet and reliable.

All are of the opinion that every effort should be made to reduce mechanical noise to a minimum by attention to all items contributing to this condition.

Most manufacturers feel that first cost is more important than weight, within limits, although they are reluctant to give definite figures. Many indicated they would accept minor increases in weight to give lower costs.

The majority think that the durability of present designs is satisfactory. All emphasized that durability should not be reduced in favor of lower costs. It was pointed out that durability is, to a large extent, a function of the per cent rated power that is used for continuous operations (Fig. 1), and that the engine manufacturer should be specific in his recommendations on maximum continuous power to be used for each engine.

Fuel and Lubrication Problems

In general it was stated that an octane rating of 80 would be satisfactory, except that the 4-5-place deluxe airplane might use 91 octane. The reaction

concluded on page 61

* Paper "Powerplant Requirements for Personal Aircraft" was presented at a meeting of the SAE Southern California Section, Los Angeles, Feb. 6, 1947; and at a meeting of the SAE San Diego Section, Feb. 7, 1947.

FUELS and E

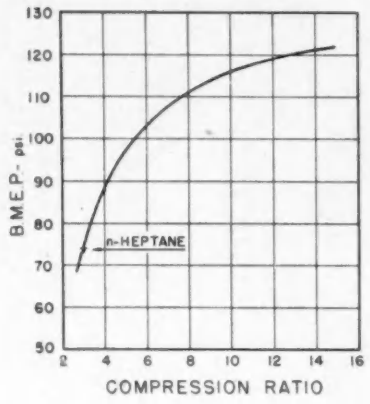


Fig. 1

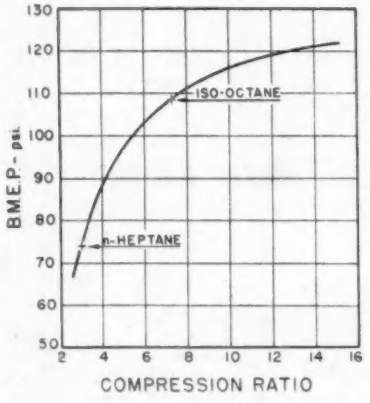


Fig. 2

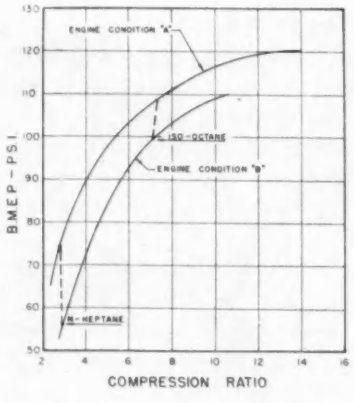


Fig. 3

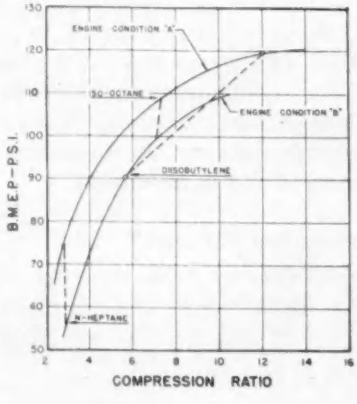


Fig. 4

CUSTOMERS only want the best possible combination of fuels and engines, and to them superlative gasolines or startling powerplants are of mere academic interest.

Although at times this mutual relationship may appear complex, there is really no reason for making a mystery of it.

As far as knock is concerned, it is trite to say that fuels and engines must be mutually adapted to each other. Specific progress can be made only through measurement of both fuels and engines in definite related terms.

It is possible to use fuels to measure engines, and to evaluate the characteristics of engines that determine what level of antiknock quality is needed to remove knock and what kind of fuel, sensitive or insensitive, is best used by the engine. These measurements are made in terms of fuels because this is the only way available at present.

Economics are in control. Improved fuels can be produced at increases in cost low enough so that when used in suitable engines the customer gets more miles per dollar. And the customer is the boss.

The fundamental facts are:

1. The knocking tendency of a fuel is a limitation to the development of work by engines. The power and thermodynamic efficiency of an engine increases as the compression ratio is increased. Fig. 1 shows a typical curve of bmep against compression ratio as obtained on one laboratory test engine under a particular set of operation conditions.

* Paper "Application of Fuels to Engines," was presented at SAE Detroit Section, Feb. 3, 1947

ENGINES

BASED ON A PAPER* BY

WHEELER G. LOVELL

RESEARCH LABORATORIES DIVISION,
GENERAL MOTORS CORP.

Increase in compression ratio represents a fundamental way of getting both more power and more efficiency out of an engine. However, this method is subject to the fundamental limitation that it can be applied only up to the point where knock begins. Every fuel knocks at compression ratios above a certain limiting value.

As shown, n-heptane, which is one particular pure fuel hydrocarbon, begins to knock at a compression ratio of about 3 to 1. With this fuel no higher compression ratios can be used under these particular conditions. The knock of the fuel thus is a limitation on what one can do with the fuel-engine combination.

2. Some fuels are freer from knock than others. For example, iso-octane, another particular pure fuel hydrocarbon, will stand in the same engine a compression ratio of 7.3 before it begins to knock, as indicated in Fig. 2. It is obviously possible to obtain more power or economy from this fuel in a suitable engine, and the increase amounts to about 50% more than n-heptane. There are experimental cars on the road which run with high compression ratio engines with superior fuels which are expected to be available in the near future.[1]

3. The incidence of knock with a fuel depends upon the kind of engine and the conditions under which it is run. For example, in Fig. 3, in addition to the previous curve of bmep against compression ratio now labeled "engine condition A," another curve has been added labeled "engine condition B." These curves represent data from the same engine – but at different speeds, jacket temperatures and

[1] See "More Efficient Utilization of Fuels" by Charles F. Kettering, SAE Journal, July, 1947, p. 31.

Fig. 5

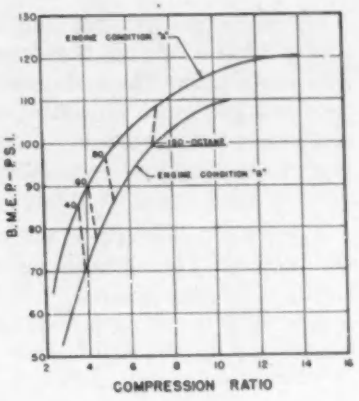


Fig. 6

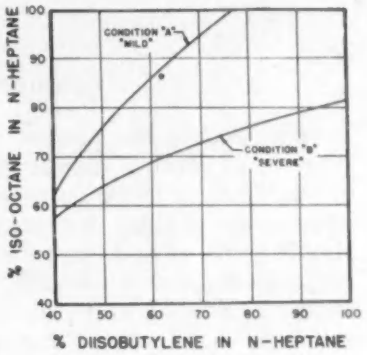


Fig. 7

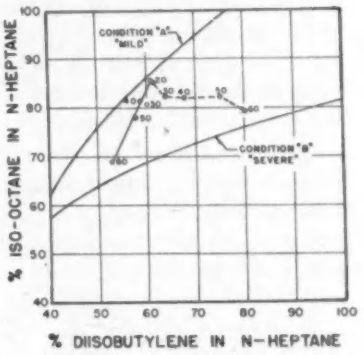
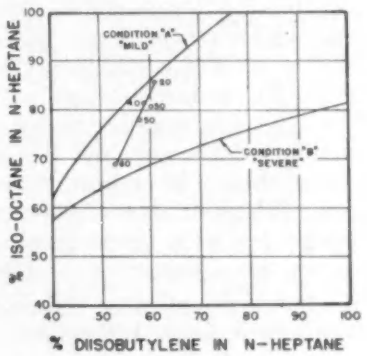


Fig. 8



inlet air temperatures. One is 600 rpm, 212 F jacket and 100 F air, and the other is 2000 rpm, 350 F jacket and 150 F air; but these values are not important for our present purposes. Although the shapes of the curves are similar, the values for the power output at either a fixed compression ratio, or with a fixed fuel differ considerably.

4. The relative superiority of a fuel depends upon the engine characteristics and operating conditions. This may be illustrated by diisobutylene, another fuel hydrocarbon whose values for the compression ratio at which knock begins are shown in Fig. 4 for engine conditions A and B. Even in the same engine, diisobutylene may be considerably inferior, or else superior, to iso-octane, depending upon the conditions under which the engine is operated.

Clear Definition Needed

This adds to the problem's complexity, because there is no general answer to the question of which of two fuels is better, unless the engine conditions under which they are used are defined. If we should think of two engine conditions as being two engines of different design, we cannot say which engine can be operated at the higher compression ratio on a so-called "available fuel," unless we know what are the characteristics of the available fuel. Is it like iso-octane, or is it like diisobutylene, for instance.

This is the background of fundamental facts. It is now necessary to answer the questions of what fuels to use in what kind of engines, and how to describe the knocking behavior of both fuels and engines in related terms. Fuel ratings are helpful in approaching engine ratings.

It is necessary to describe the relative freedom from knock of a fuel. Fuels have been usefully defined or rated only by comparison with other fuels and specifically in terms of mixtures of heptane and iso-octane to give rise to the octane number scale.

In Fig. 5 values for the critical compression ratios of different percentages of heptane in octane have been plotted on the bmep – compression ratio curves.

A fuel's octane number is the percentage of iso-octane in heptane which just matches the knock of the fuel when both are burned in an engine under some specified conditions. From these data one can estimate octane numbers of diisobutylene. By making the comparison under engine conditions A, diisobutylene appears better than iso-octane or more than 100 octane number. By making the comparison under engine conditions B, diisobutylene is about equal to 85 octane number.

The Motor method or ASTM octane number of a fuel is based on a comparison of the fuel with heptane-octane mixtures in a standard CFR laboratory engine under certain rigorously specified conditions. The Research method octane number is based on a similar comparison in a similar engine under other conditions. The ASTM octane number of diisobutylene is about 88 and the Research is about 100, for example.

Reasons for Method

Reason for choosing the engine test methods shown in Figs. 3, 4, and 5 is two-fold. These methods give octane numbers to fuels of widely varying types which are in fairly close approximation to those obtained for the same fuels when tested by the Research and Motor methods. Engine conditions A and B are those used among others for rating a wide variety of pure hydrocarbons by an American Petroleum Institute research project to facilitate comparison with hundreds of pure hydrocarbon fuel compounds.

The obvious solution is to rate fuels in cars on the road, and then select the test method that corresponds best. This is an operation that must be conducted with great care.

Engine rating is the other side of the fuel rating problem. An engine must be described in terms of what kind of fuel it requires to be free from knock. This can be done only in terms of available reference fuels.

There are millions of cars on the road. They are made, they are in use, there is not much that can be done about them, as far as fuels are concerned.

Engines that haven't been made yet are a problem for engine designers. They must secure a high level of performance with the cheapest possible fuel at a given antiknock level. Generally, fuels of a given antiknock level are cheaper when their value changes greatly with engine condition. Such fuels are usually called "sensitive" fuels in contrast to "non-sensitive" fuels of the iso-octane type.

Similarly, engines, or engine conditions that lower the value of "sensitive" fuels are called "severe," in contrast to "mild" engine conditions. It is to the advantage of the public to have future engines of a "mild" type so they can use the fundamentally cheaper "sensitive" fuels. In the past engines have not always been of that type.

Measuring for Severity

Engines, then, must be measured for severity. To a large extent this can be done experimentally by testing diisobutylene mixtures in an automobile and comparing them with iso-octane mixtures. Because cars should operate on a fixed compression ratio over a range of conditions, it is necessary to use known mixtures of the pure compounds so that the level of antiknock quality may be varied to produce incipient knock.

By comparing mixtures of diisobutylene in heptane with mixtures of iso-octane in heptane, and

replotting the data of Fig. 5, the diagram shows the percent of diisobutylene in heptane which, in an engine, just matches various percentages of iso-octane in heptane. This result is shown in Fig. 6, one curve for the A engine conditions and one for the B engine conditions.

Determining Severity

If an automobile operates under some specific condition at a speed of 20 mph, it may be found that 64% diisobutylene in heptane just knocks, and 87% of iso-octane just knocks. The two are thus equivalent, and may be plotted as a point on Fig. 6. The location of the point represents an index of severity in the automobile engine. The closer the point to the upper curve the closer does the total effect of the engine conditions in the automobile approach those represented by the A engine conditions or the Research octane number or a very mild engine, at least as far as diisobutylene is concerned. The closer to the bottom curve, the closer to the severe B conditions test engine, or the Motor conditions. The degree of severity in the car engine is found fairly directly.

Such mixtures may offer some advantages and disadvantages in measurements in automobile engines. The three materials are readily obtainable in a fairly pure state at reasonable prices for engineering work, and are duplicable and readily described to form a permanent scale. Heptane and iso-octane are also the primary reference fuels. Also, the physical properties of the fuels are quite similar, and even the boiling points of all three compounds are within 10 F of each other. Furthermore, the mixtures are usable and automobiles do operate quite satisfactorily on them.

Chief disadvantages of using these mixtures to measure engine severity lie in the interpretation of the data in practical and commercial relations. The fuels cover a limited range of antiknock level and measurements, under severe conditions. But that range seems sufficient. The difference between the Research and ASTM ratings varies with the general antiknock level, and that the diisobutylene-heptane mixtures of varied antiknock level do not have a constant sensitivity. This should be borne in mind. These pure fuels do not contain lead, as do most commercial gasolines, and they also have an almost constant boiling point instead of the range of boiling points of commercial gasolines. The inspection of the large amount of data on other pure compounds showing their characteristics has not yet indicated this to be a very serious disadvantage and a compound superior to diisobutylene for this purpose has not yet appeared.

As a specific example of using these fuels to determine how engine knock is affected by operating conditions, Fig. 7 shows that the ratings at 20, 30, 40, 50 and 60 mph lie pretty well on the heavy solid line. And up to 30 or 40 mph, the engine is mild, but at 60 mph it gets quite severe. If we run the car on a fuel such that it does not knock too badly at the low speeds, it won't knock at high speeds at all. This, then is a very mild automobile engine.

But, if we take this same car, with the same spark advance but change the operating conditions so that there is more opportunity for hot-spots in the combustion chamber, we get a severity pattern of the car to look like the dotted curve which has been added to make Fig. 8. So over the speed range, the car now comes out as a pretty severe one, and 80% diisobutylene will come out, considering the whole speed range, as about equal to 85% octane.

Such a car as represented by the dotted line of Fig. 8 penalizes fuels of the diisobutylene type – the so-called sensitive fuels which are the cheaper ones to make. And this is obviously an undesirable situation for the customer and consequently all concerned.

■

LOW-HP ENGINES

cont. from p. 57

to the use of premium auto fuel was favorable if quality and vapor pressure are controlled for hot-weather operation.

Engines, it was considered, should start easily at 10 F and should require no special starting fuels.

The injection system is preferred to the use of the carburetor.

Although most manufacturers favor the wet sump, many like the dry sump. It was suggested that in any case the sump and oil system be designed to permit a 20-deg climb and a 20-deg glide. It is felt that an oil cooler should not be necessary with correct cowling design, but that there should be provision for such installation, if it is desired. Oil filters are thought to be desirable and should be an integral part of the oil system.

Gas Turbines

The gas turbine has not reached the stage where it should be considered for low-horsepower engines. However, several suggested a gas turbine engine of 300 hp should be considered, with goals set at 0.6 lb per bhp-hr fuel consumption and a weight of 150 lb including starter, price to be $1500.

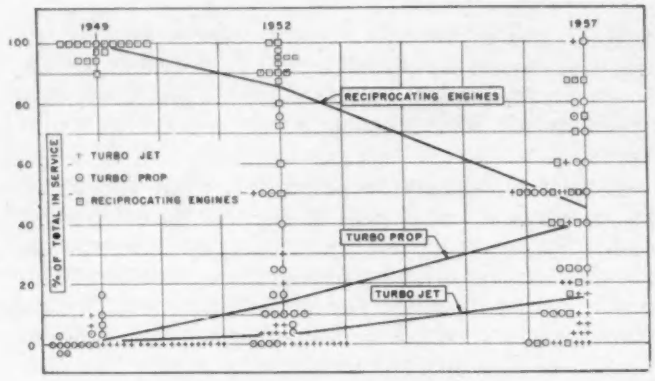


Fig. 1 – Commercial air transport future

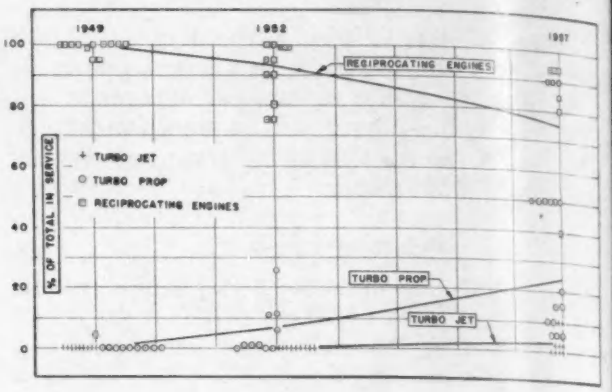


Fig. 2 – Cargo aircraft future

(This paper will be published in full in SAE Quarterly Transactions)

Aircraft POWERPLANT

THE reciprocating engine will continue to occupy an important place among aircraft powerplants throughout the next ten years. But as gas turbine powerplants are improved and higher flight velocities become feasible, the airlines will turn to the turboprop and the military services to the turbojet. In the light-aircraft field, the reciprocating engine will be almost unchallenged.

Progress will be made on all three types of powerplant – the emphasis in engineering effort being placed on developing larger and larger horsepower outputs and, at the same time, driving down fuel consumption figures.

These are the trends indicated by a survey of what engineers expect in aircraft powerplants in service two, five, and ten years from now. Questionnaires were sent to men active in aircraft engine design, airline operation, government agencies, equipment supply concerns, and petroleum companies, in Canada and England as well as in this country. Those replying gave their personal views – not necessarily the views of their organizations – based on the assumption that development will continue at its present rate.

Generally, the experts agreed fairly closely on what could be expected in 1949, but in some cases, they differ considerably on the prospects for 1957. In interpreting the results of the survey, the arithmetic average of the replies on each question has been taken as indicative of the trend.

Behind many of the predictions is the fact that selection of powerplants for various types of aircraft depends largely on the relative importance of power or speed, and fuel economy. It is usually recognized that, of the three varieties of powerplants considered, turbojets are the best suited to extreme high-power, high-speed applications. Turboprops come next, and reciprocating engines last. With fuel economy as the standard for selection, the order of superiority is reversed, at least at the present time – reciprocating engines are most economical, turboprops next, and turbojets least economical. Fuel economy of the turboprop may improve

Fig. 4 – Bomber aircraft future

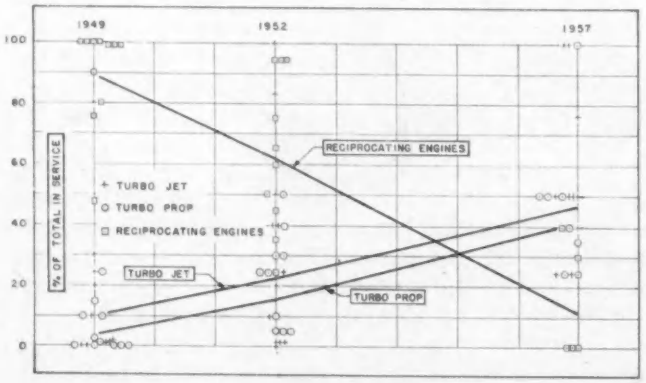
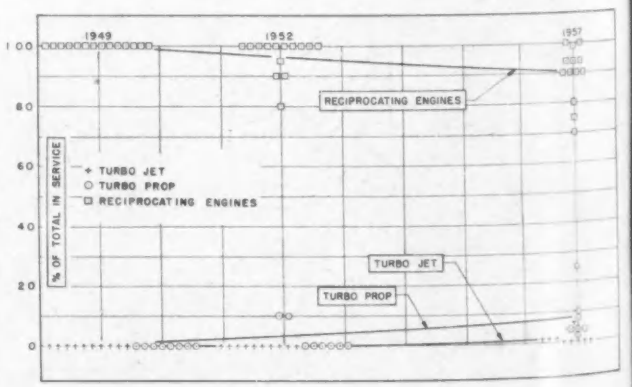


Fig. 5 – Private-owner aircraft future



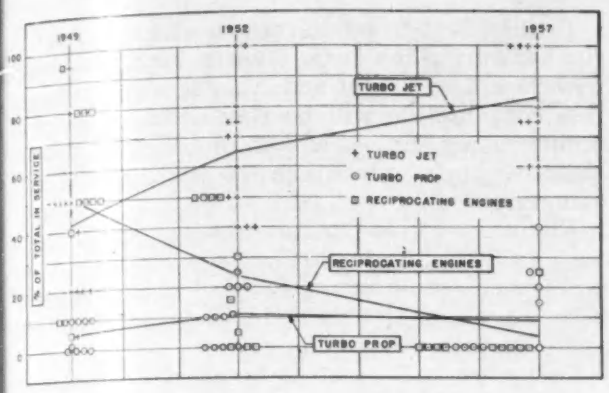


Fig. 3 – Fighter aircraft future

PREDICTIONS

FROM A PAPER* BY

A. T. GREGORY, Chief Engineer

and

A. L. POMEROY, Engineering Operations Manager

RANGER AIRCRAFT ENGINES

faster than that of the reciprocating engine so that the two become comparable by 1957, but the economy of the turbojet will become comparable only when very high flight speeds are reached.

In the airlines field, the desire for more and more speed in transports is not expected to outmode the reciprocating engine during the next ten years. In fact, it will be more popular than either the turboprop or the turbojet even in 1957, the survey indicates.

Fig. 1 shows the engineers' estimates of the popularity of the three types of powerplant for transports from 1949 to 1957. Arithmetic averages of the values reported have been plotted, and the curves are drawn through the points. According to the curves, practically all transports will still be propelled by reciprocating engines in 1949. The percentage will drop after 1952, until by 1957, reciprocating engines power about 45% of the planes. Turboprops will rise to about 15% in 1952 and 40% in 1957.

It appears that turbojets may be used in a few aircraft to provide a luxury service where speed is the first consideration. The turbojet begins to show its advantage over the other two types only when speeds of 500 to 600 mph are reached. There is a great deal to be learned between today, when we are only beginning to fly commercially at speeds over 300 mph, and the day when speeds over 500 mph are reached in regular commercial passenger service.

Powerplants for commercial cargo aircraft are selected for economy of operation rather than for speed. The low specific fuel consumption of the reciprocating engine will help it to maintain its reigning position for the next five years. But, by 1957, the light weight and good fuel economy of the turboprop should make it a competitor. Very few turbojet aircraft are expected to be used in cargo service. Fig. 2 gives the predictions for cargo aircraft.

Airlines will be influenced in their selection of powerplants by first cost and maintenance costs as

*Paper "Future Trends in Aircraft Engine Design," was presented at SAE National Aeronautic Meeting, on April 9, 1947.

Fig. 6 – Executive-transport aircraft future

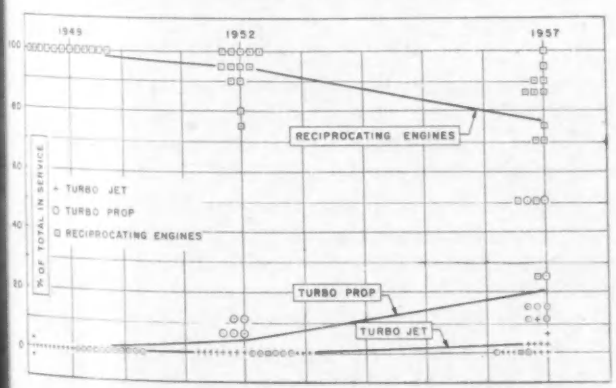
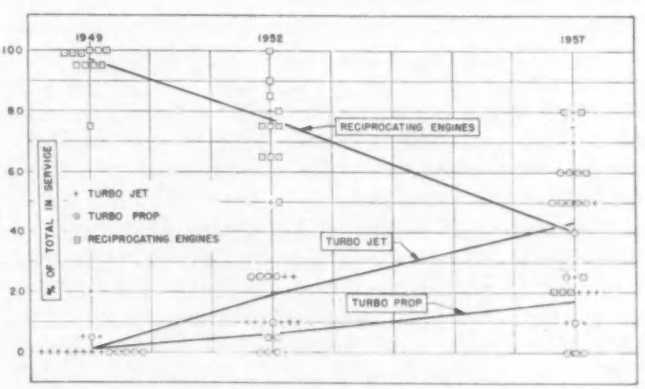


Fig. 7 – Trainer aircraft future



well as by speed and economy. Eventually, the turboprop will cost less per horsepower than the reciprocating engine, the experts prophesy. (Jet engines will cost even less per horsepower.)

They say also that periods between gas turbine overhauls will not catch up to the overhaul periods for reciprocating engines within the next ten years. On the other hand, fewer manhours are required for overhauling and for servicing the gas turbines. The result is that for a given fleet of planes, turboprops now require a ground crew two and a half times as large as the staff required by reciprocating engines. But, by 1957, the turboprop staff will be only about 20% larger. (Turbojets will be operated then with a ground staff about 10% smaller than a corresponding staff for reciprocating engines.) At the close of the 10-year period, 1200-hr periods between overhauls are forecast for reciprocating engines, and the ground staff need be only 90% of its present size to care for the same number of planes.

Fighters First to Switch

Fighter planes will be the first type to switch to turbine powerplants, according to the survey (Fig. 3). An average of the percentages of turbojets, turboprops, and reciprocating engines predicted to be in service in 1949 shows that the fighter types will be about evenly divided between reciprocating and turbojet engines then. The percentage of planes powered by turbojets will increase to about 65% in 1952 and to about 80% in 1957. Throughout the 10-year period, the turboprop will power only from 5 to 10% of all fighters.

Again in the field of bombing planes, it is foreseen (Fig. 4) that reciprocating engines will be replaced quite rapidly with turbine engines. Their use will increase until in 1957 they power an estimated 90% of the bombers. The predicted percentages of turboprops and turbojets are about equal throughout the ten-year period, the turbojet consistently having a slight edge.

The reciprocating engine will predominate throughout the 10-year period in light aircraft, it was agreed. And light aircraft are numerically very important – private-owner types alone constitute about 85% of our nonmilitary aircraft and number over 67,000 airplanes at the present time. Figs. 5 and 6 show that turboprops will power only about 10% of the private-owner types and 20% of the executive-transport types by 1950. The percentage of turbojet aircraft will be very low. Delays at airports and traveling time to and from airports overshadow the time saving possible with a turbojet's higher speed.

Light aircraft designed for training use will reflect the military trends, except that there will be more lag in switching to gas turbines. About 75% of the trainers will have reciprocating engines in 1952, the proportion falling off to about 40% in 1957, according to Fig. 7.

In the effort to refine reciprocating engines still further during the next 10 years, higher maximum powers will be sought and every means of reducing fuel consumption will be considered. Backers of reciprocating engines will do their best to preserve their engine's advantage in specific fuel consumption.

Engineers foresee reciprocating engines rated as high as 5000 bhp by 1957. They also foresee engines with optimum specific fuel consumptions of 0.39 lb per bhp-hr obtained without compounding, and 0.33 with compounding.

Designers will make a number of changes to achieve these higher powers and fuel economies. Compression ratios are expected to rise from the prevailing value of 6.7:1 to around 9.4:1 in 1957. Maximum bmep for take-off and emergency will rise from 240 to 310 psi. These bmep's will be reached by raising manifold pressure. By 1957, peak power outputs will call for manifold pressures on the order of 80 in. of hg, generated by direct-driven superchargers.

Lessons in turbine design learned from experience with gas turbine powerplants will be applied in supercharging and compounding. Compounding will be considered, at least, for any operation where fuel economy is the governing factor, even in engine sizes as small as 1000 or 500 hp.

Liquid injection of a water-alcohol mixture promises to be both a substitute for higher-octane fuels and a means of satisfying peak cooling requirements. But it will be used only for take-off and emergency operation. Water consumption is too high for use at cruise.

Some experts are counting on seeing variable valve-timing arrangements, perhaps involving special camshafts, introduced to improve fuel consumption characteristics in the cruising range and to increase power for take-off. The JATO form of thrust augmentation, which has already been CAA-approved for commercial use, is likely to come into wider use.

Pressure-type carburetion will be the means of fuel metering for the majority of reciprocating engines during the 10-year period, the replies indicate. Development costs of fuel injection will be too high to warrant its introduction except for long range, high-power engines.

Small Reciprocating Engines

In the field of small reciprocating engines (around 110 hp) there will probably be more flat-opposed types than radial or inline types. Few people expect to see any 2-stroke cycle engines.

New designs will aim at lower fuel consumption following some of the trends talked of for large engines. Fuel consumption may drop from the current value of about 0.50 lb per bhp-hr to 0.43 lb per bhp-hr in 1952 and 0.41 lb per bhp-hr in 1957.

Estimates are that compression ratios will reach 7:1 in 1949, 8:1 in 1952, and 9:1 in 1957. Piston

speeds may go up to the 3000-fpm range, and bmep's will rise. Appearance of a few gear-driven superchargers is predicted toward the end of the 10-year period.

Fuel injection into the intake manifold will undoubtedly be offered as optional equipment on more and more engines. An increasing number of engines will also incorporate reduction gears to take advantage of better propeller efficiency and raised ratings on existing engines. Many items of automotive equipment such as starters, fuel pumps, and batteries will probably be adapted for use on private-owner planes.

Turboprop Development

A large portion of the available engineering effort is being expended on the turboprop. Reasons for this are that a given amount of effort will probably produce a greater improvement in the turboprop than in the reciprocating engine, and as flying speeds increase, the range where the turboprop is the most efficient type of powerplant will be reached before the turbojet's range.

The turboprop has been generally considered best suited for very large horsepower sizes – above those reached by reciprocating engines. Engineers are looking toward maximum outputs of 6500 hp in 1952 and 10,000 hp in 1957.

On the small side of the picture, many engineers expect to see some turboprops in sizes for light aircraft developed during the next ten years. Their conceptions of "small" turboprops vary considerably, but the average figures show they look for turboprops as small as 550 hp by 1949 and 250 hp by 1957.

In the matter of fuel consumption, the turboprop is superior to the turbojet, especially at moderate flight speeds. At present, the turboprop is inferior to the reciprocating engine on a lb fuel per bhp-hr basis. But that does not take airplane performance into consideration. It may be that turboprops will excel in fuel economy figured on a mileage basis. This depends on the relative performance of airplanes using turboprops and airplanes using reciprocating engines.

Opinion is generally that the turboprop engine of the future will employ some method of power augmentation. Since fuel consumption is extremely important, the method which satisfies requirements for peak power in the most efficient manner will be the method used. Liquid ingestion and turbine interstage reheat look like the best bets to many investigators. After-burning gives high thrust increases, but fuel consumption is very high.

Regeneration may be used to improve turboprop fuel economy, although it decreases the quantity of fuel needed to obtain the turbine entrance temperature at the expense of a pressure drop in the working fluid and increased weight, bulk, and complexity of the powerplant.

The turbojet is a simple form of powerplant capable of very high power output. Military demands for high speed will undoubtedly create demand for the turbojet's high power. However, high speeds introduce problems with the airplane which must be solved before the high-power engine can be used effectively. Although the trend in powerplants is toward larger and larger horsepower sizes, these airplane problems may slow turbojet development in the future.

Estimates of maximum thrust output of turbojets averaged around 11,000 lb for 1952 and around 16,000 lb for 1957. The present maximum is about 4000 lb thrust.

Specific fuel consumption for turbojets is usually stated in terms of lb per lb thrust – it can be stated in terms of lb per bhp-hr only when airplane speed is known since the engine delivers more horsepower for a given thrust as airplane speed is increased. Estimates of thrust specific fuel consumption average about 0.8 lb per lb thrust by 1957, or about a 20% improvement over the present value of 1.0 lb per lb thrust.

For short bursts of very high thrust during takeoff, emergency, or military-power operation, several forms of thrust augmentation are under consideration. After-burning produces tremendous increases in thrust; preliminary investigations have shown increases up to 70%, and increases of 100 to 150% may be obtained later. Of course, these gains are made at the expense of enormously high fuel consumption, which can be maintained only for limited periods.

Liquid ingestion will produce thrust increases of 25 to 50% without any increase in fuel consumption. A design combining after-burning and liquid ingestion might make possible thrust increases of 100 to 200%, but the powerplant would be heavy and complex.

Another arrangement which may appear as a means of thrust augmentation is the so-called ducted fan, which supplements the thrust of the main jet at intermediate flight velocities. Increases of about 80% of the jet's thrust can be expected. The arrangement makes good use of the higher ram pressures available at higher velocities.

Higher Pressures, Temperatures

Good performance of gas turbine powerplants depends a great deal on favorable compressor characteristics and high burner temperature. The high efficiencies obtainable even at high pressure ratios with the axial-flow compressor and its simplicity will make it three times as popular as the centrifugal compressor by 1957. Turbojets will not use very high compressor pressure ratios because the high velocities which they entail would be beyond the Mach number limitations of the jet.

Engineers are counting on advances in materials and new designs for air-cooling or liquid-cooling turbine blades and discs to make it possible to raise operating temperatures. Predictions of the maxi-

mum peak operating temperature in 1957 range from 1500 to 3200 F, the latter used with liquid cooling of the blades and for short periods only. Predictions averaged about 2200 F.

Petroleum producers and engine builders are divided over the question of fuels for gas turbine powerplants. The petroleum men believe a single fuel will satisfy both turboprop and turbojet requirements. Their opinion is that the better grades of kerosene now being used will not be available in sufficiently large quantities to meet the demand throughout the next ten years. Instead of the AN-F-32 and AN-F-34 fuels, they expect a fuel containing relatively large amounts of aromatics. Engine builders point out that the inclusion of a substantial percentage of aromatics may be reflected in poorer performance. It has been stated that turbojet engines, because of their high-speed application, may require fuel with a high heat content per unit volume, whereas high heat content per unit weight may be more desirable for turboprops.

From the standpoint of availability at no sacrifice in engine performance, several investigators foretell the use of a nonleaded, low-octane, motor-type gasoline of the straight-run variety. The price differential between this and the more scarce kerosene might overbalance the penalty of the gasoline's lower heat content.

HYDRAULIC ROTARY DRIVES

continued from page 42

gine speed to be able to develop full sea-level refrigeration.

This increase in engine speed is not sufficient to overheat the engines. But it increases the drag in the brakes, burns more gasoline, creates more noise, and, if the pilot does not notice that increased rpm is required, will reduce the amount of cabin cooling available from the system. However, the real limit to this slip is its own horsepower loss in the bridle circuit. This heat must be carried away by the cooling oil and dissipated in the oil cooler (which of course does not have unlimited capacity) without causing excessive operating temperatures.

Another interesting problem was the determination of the relief valve setting for the bridle circuit.

If this valve opens and fails to reseat reasonably well, its leakage will have the same effect as excessive internal leakage within the hydraulic motor-pump units, causing overheating, horsepower loss, and inability to develop maximum step-up ratio of the variable speed drive. If this valve is set too high in an effort to assure reseating, excessive loads will occur throughout the system when some transient condition occurs that is sufficiently severe to open the valve.

The difference between unseat and reseat pressures for a relief valve often depends on the rate at which oil passes through the valve. This is a function of the magnitude of the disturbance that opens the valve. If the valve passes only a slight amount of oil, it may reseat readily. If a large quantity is passed in the same time interval, it may reseat much less readily.

The optimum setting for the bridle-circuit relief valve depended in part on the functioning of the supercharger flow-control circuit. If the transient engine rpm change were such as to cause gradual unseating of the relief valve, it reseated readily at a safe margin above operating pressure. If the transient were violent, the flow-control valve obligingly overcontrolled. This permitted the operating pressure to fall considerably below final equilibrium pressure and allowed the relief valve to reseat before the pressure rose to its final value.

A great deal of effort has been spent in the development of the entire supercharger system. Six different power drives have been used in research tests: a 2100-hp airplane engine, three smaller internal combustion engines, and two electric motor drives. As many as four of these drives operated simultaneously to work out design problems of hydraulic or mechanical natures. Testing in a refrigerated altitude chamber has been almost continuous over a period of a year and a half.

Every single unit produced is run 7-hr under a loading schedule which gradually exercises each and every bearing, gear, and hydraulic unit, beginning with low speed and low load conditions, and finally exceeding anything that will be encountered in flight. After this workout, the entire supercharger power package is disassembled, inspected, reassembled, remounted on the test stand, and rerun another 2 hr before being certified as ready for installation in an airplane.

It is not often that hydraulics ventures outside its proven field of straight line motion. It seemed like quite an assault on sacred hydraulics territory when electricity – with its essentially rotary motion – scored considerable success with electric-powered jacks, cowl flaps, and other units.

Now hydraulics has been first in the new field of driving variable-speed centrifugal compressors for cabin supercharging. Electricity might challenge this monopoly; but if some fresh new rival is first to try, many will not be surprised.

BEECROFT Memorial Lecturer

Paul G. Hoffman

FOR "substantial contributions to the safety of traffic involving the use of motor vehicles," Paul G. Hoffman, president of Studebaker Corp., has been named by the Society of Automotive Engineers as the first Beecroft Memorial Lecturer.

He will be the first of 10 distinguished Americans to be honored during the next decade under terms of a bequest to the SAE by its former president, the late David Beecroft.

Announcement of Mr. Hoffman's selection was made by Pyke Johnson, as chairman and representative of SAE on a special award committee. Other organizations represented on the committee are the American Association of Motor Vehicle Administrators; the Automobile Manufacturers Association; the Automotive Safety Foundation; the American Association of State Highway Officials; the International Association of Chiefs of Police, and the Public Roads Administration.

Mr. Hoffman will deliver the 1947 lecture in Chicago on Oct. 14 at a meeting sponsored by the Chicago Section of the SAE.

An active force in highway accident prevention since his early days as an automobile distributor in Los Angeles, Mr. Hoffman has devoted more time and effective effort to safety than any other executive in the motor industries. He is chairman of the Automotive Safety Foundation, and served in 1946 and 1947 as chairman of the Organized Public Support committee of the President's Highway Safety Conference.

The late David Beecroft as he appeared in 1921 when he was president of the Society of Automotive Engineers

The Beecroft Memorial Lectures are the result of a $2500 bequest to the Society by Past-President David Beecroft.

The money was to be used, Beecroft's will specified, "for ten awards of $250 each to be awarded at the sole discretion of the Past-Presidents Committee with the hope on my part, however, that the awards will be made for meritorious contributions to the improvement of traffic conditions . . . ."

The Council, on June 5, 1946, approved the Beecroft Memorial Lectures series recommended by its Past-Presidents Committee as the method of administering the bequest.

2 WAYS to Match WING

Plot Gross Weight Versus Wing Area

Say H. H. CHERRY
and
A. B. CROSHERE, JR.
Douglas Aircraft Co., Inc.

(Based on a paper which will be published in full in SAE Quarterly Transactions.)

PLOTS of allowable gross weight versus wing area for various conditions of cruising speed, range, take-off distance, operating cost, and other such specifications can be a big help in preliminary design of aircraft. They offer one way to find out what combinations of wing area and gross weight will result in an airplane which meets the specifications laid down for it.

The specifications are considered one at a time. Take, for example, the operating-cost specification and assume that cost shall not exceed $0.20 per ton-mile. Operating cost in those units can be computed for a desired payload by the Air Transport Association's cost equations. (Range and cruising speed are specified, so that block speed can be found. Other variables are estimated.)

Operating cost is calculated for a range of combinations of gross weight and wing area. Then it is plotted versus gross weight with wing area as the parameter. Next a crossplot is made of gross weight versus wing area for constant values of operating cost. Fig. 1 shows a sample crossplot. Several lower values of cost, as well as the maximum, are plotted. The lower values are needed to indicate the "safe" side of the maximum curve.

Similar procedures are followed with each of the major specifications. Requirements imposed by the CAR can also be handled the same way.

Finally a summary chart is prepared showing the range of combinations of gross-weight and wing-area values which will satisfy all of the major specifications. Fig. 2 gives the heart of such a summary. The area inside the polygon ABCDEF is on the "safe" side of all the specifications.

When the specifications are mutually exclusive, there is no positive area bounded by all of the specification curves.

The airplane defined by point A of Fig. 2 has the greatest cruising speed, that by point B has the shortest required take-off distance, and that by point D has the greatest range. Any point within the boundaries will exceed all the limitations. With the chart, improvement in one item of performance can be evaluated in terms of its effects on other items. (Paper "An Approach to the Analytical Design of Aircraft," presented at SAE National Aeronautic Meeting, on April 10, 1947.)

Plot Power Loading Versus Wing Loading

Says JOHN E. STEINER
Boeing Aircraft Co.

(Based on a paper which will be published in full in SAE Quarterly Transactions.)

PLOTS of power loading versus wing loading, on which climb require-

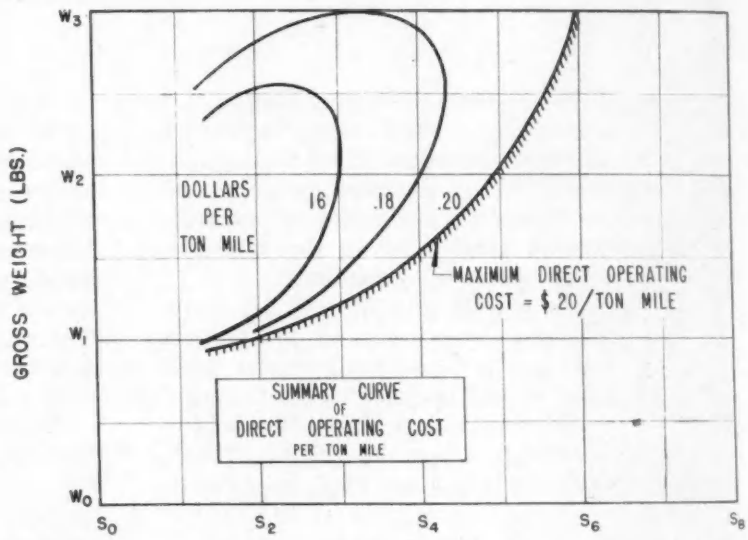
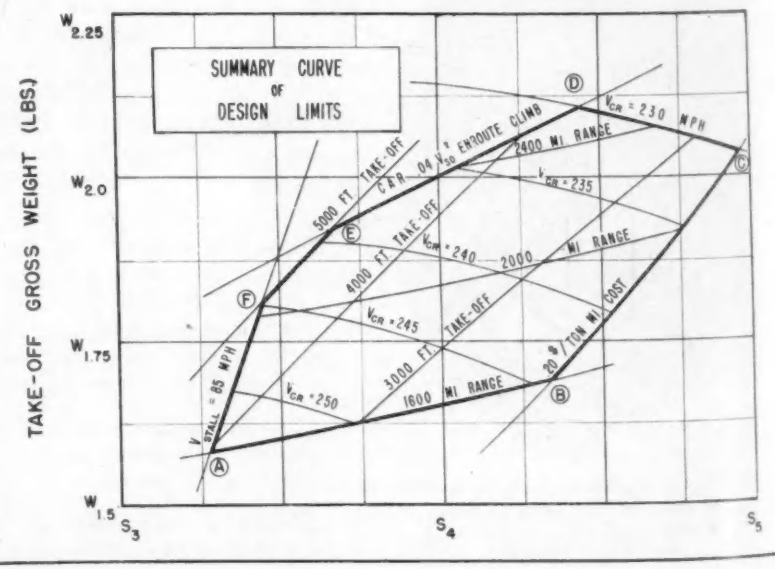


Fig. 1 (above) – Sample chart of variation of operating cost with gross weight and wing area

Fig. 2 (below) – Heart of summary plot indicating allowable combinations of gross weight and wing area



and WEIGHT

ments of the Civil Air Regulations appear as boundaries, will define what combinations of loadings and gross weights are allowable. These plots will show which climb requirement is critical and what effect airplane configuration will have on gross weight.

This method of analysis involves airplane wing loading, W/S, take-off power loading, W/P, and the ratio of take-off power to wing area, P/S. A plot of power loading versus wing loading, similar to Fig. 3, is used. A radial line passing through the origin will be a line of constant P/S. For any one airplane, P/S is a constant; therefore, the plane can be represented by a radial line.

As the airplane is loaded heavier and heavier, points representing the plane will move out along the line of constant P/S. But performance will decrease, until at some point it just meets one of the CAR climb requirements. Further loading will not be allowable.

These maximum allowable loading points can be found for various P/S values and joined together to form a curve of maximum loading for a specific regulation. Maximum-loading curves should be determined for several values in the range of possible aspect ratios. The area bounded by a maximum loading curve and the axes determines the characteristics of planes which will satisfy a given CAR climb requirement.

There are several kinds of climb requirements such as all-engine climb and enroute climb at various altitudes. Charts of power loading versus wing loading must be determined for each kind of climb.

Landing-field lengths required by the CAR and cruising speeds resulting from the powers considered may be added to the plots. Then the designer may select the characteristics of the fastest, most heavily loaded airplane which may be built within the CAR for operation from a known airport size. (Paper "The Effect of Civil Air Regulation Performance Requirements on Airplane Design," presented at SAE National Aeronautic Meeting, on April 11, 1947.)

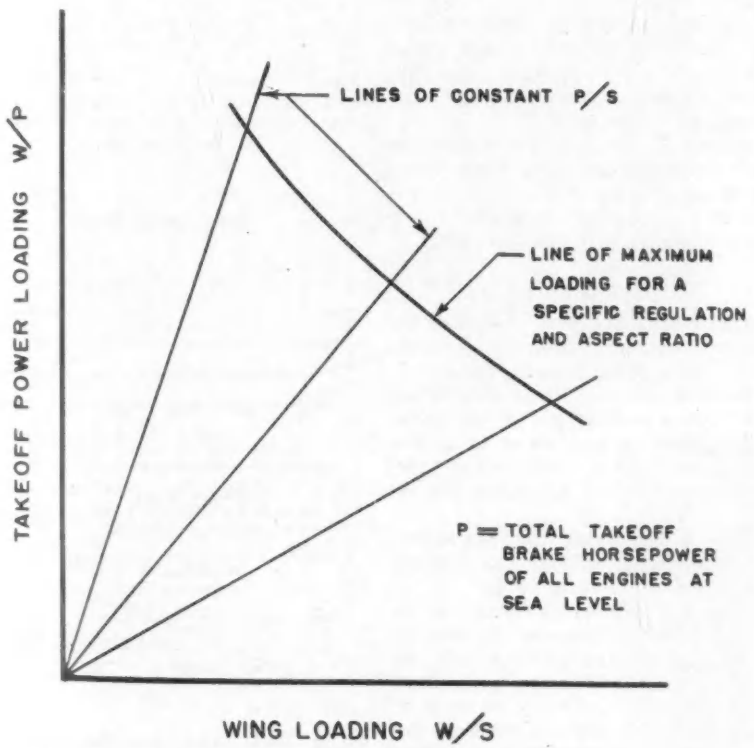

LINES OF CONSTANT P/S
LINE OF MAXIMUM LOADING FOR A SPECIFIC REGULATION AND ASPECT RATIO
P = TOTAL TAKEOFF BRAKE HORSEPOWER OF ALL ENGINES AT SEA LEVEL
TAKEOFF POWER LOADING W/P
WING LOADING W/S

Fig. 3 – Plotting form used for power loading versus wing loading method

Vehicle Diesel Rise Credited to Publicity

Based on a paper

By D. J. CUMMINS

Cummins Engine Co., Inc.

HIGHLY publicized stunts won the diesel its role as a truck and bus engine by demonstrating its performance and operational characteristics to large fleet owners.

Confined to marine applications until 1929, Cummins embarked on a campaign to prove that an automotive diesel could be built and operated successfully.

First of a series of planned events was to drive an old Packard sedan powered with a 4-cyl diesel from Columbus to New York as an exhibit in the autoshow. The same 4-cyl engine was then placed in a race car which ran a nonstop 500-mph race and averaged 86.5 mph. In 1932, Cummins' first full automotive engine created a new AAA nonstop record of 14,600 miles.

The following year saw a 32-passenger bus, rebuilt with a diesel, make a transcontinental test run.

All of this testing helped work out a number of bugs and also interested several major truck lines in installing quite a few engines. This sped up development by building up many service miles. (Paper "A Brief Outline of the Developments of the Cummins Diesel Engine," was presented at SAE Western Michigan Section, Jan. 23, 1947.)

NACA Gage Measures Piston-Ring Forces

Digest of paper

By M. C. SHAW, C. D. STRANG, and O. W. HART

National Advisory Committee for Aeronautics

(This paper will be published in full in SAE Quarterly Transactions)

A 12-POSITION gage has been designed and used successfully by the NACA to determine the radial pressure distribution of a piston ring compressed to cylinder diameter.

There is interest in piston-ring radial pressure distributions because, in studies of ring sticking, ring flutter, and cylinder oil consumption, the reproducibility of data depends partly on the use of piston rings having similar radial-pressure distributions. Also, the radial-pressure pattern is a useful criterion of quality in the manufacture of piston rings.

The authors give the details of their

experimental method. Some of the conclusions they reach are:

A cylinder that is out-of-round by as little as 0.005 in. is capable of significantly affecting the radial-pressure pattern of a piston ring.

A piston ring showing uniform radial pressure when compressed to an exact circular shape will not necessarily show a uniform radial-force pattern when compressed to cylinder diameter by a finite number of load-measuring elements.

The radial-force distribution of both cast-iron and steel piston rings varied with the strain history of the ring. In an effort to reduce the observed variation in force distributions with time, the rings were subjected to a number of stress cycles just prior to test. The procedure improved reproducibility with steel rings but had a detrimental effect on reproducibility with cast-iron rings. (Paper "NACA Study of Measurement of Piston-Ring Radial-Pressure Distribution," presented at SAE Annual Meeting, on Jan. 7, 1947.)

Air Transport Cost Factors Considered

Digest of paper

By B. B. MASTERSON and C. F. THOMAS

Lockheed Aircraft Corp.

(This paper will be published in full in SAE Quarterly Transactions)

SOME factors influencing operating cost analyses of transport aircraft are examined by Masterson and Thomas. Using the Air Transport Association's equations for direct operating costs of airline aircraft, the authors find that:

Ground and direct cost varies directly with payload and with number of stations in the system. Ground and indirect costs tend to decrease as length of passenger journey increases, although high food expenses for flights of about 3- to 4-hr duration result in a slight peak at about 800 miles.

As cargo, freight, and mail become larger portions of the payload, indirect costs decrease for a given payload.

A study of actual conditions shows that estimating indirect cost by assuming a constant ratio of indirect cost per mile to direct cost per mile can lead to incorrect conclusions.

Simple equations will help indicate the effects of varying speed, fuel cost, number in crew, and utilization.

Profit-potential graphs form a convenient method of comparing the relative merits of several aircraft for known conditions. (Paper "Some Factors Influencing Operating Cost Analyses of Transport Aircraft," presented at SAE Los Angeles Section, Dec. 12, 1946.)

Traces To

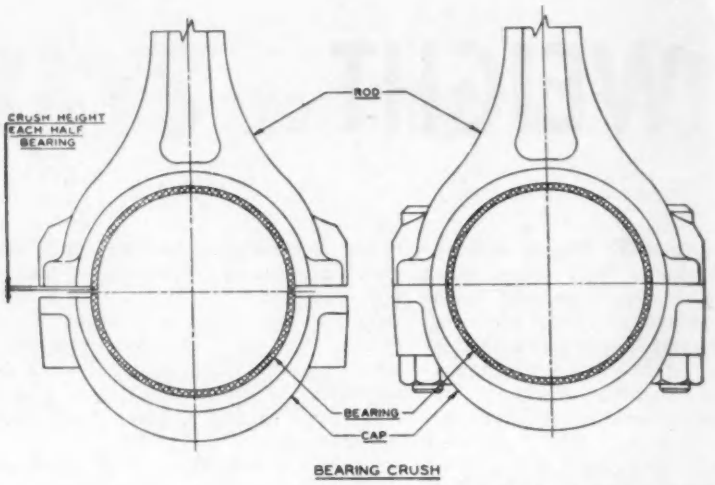


Fig. 1 – Snug-fitting bearings result from proper crush – the difference in vertical height between bearing half and bore

Digest of paper

By EDWIN CRANKSHAW

The Cleveland Graphite Bronze Co.

CARE in assembling and operating vehicle engines is the touchstone to long life and satisfactory performance of precision bearings, shows Crankshaw. Improper bearing fits, accumulated dirt during engine assembly, and bad driving practices doom bearings to early breakdown.

Bearings can be installed to fit tightly by providing the proper crush. Crush, as shown in Fig. 1, is the amount of vertical height by which the bearing half exceeds the half diameter of the bore into which it is assembled. Drawing the assembly up tight thus assures a good contact between bearing back and bore seat.

A proper set of standards for bearing crush – developed through experience – must be adhered to. Leaving crush determination to the individual mechanic's discretion invites trouble.

Too Little Crush

Insufficient crush, Fig. 2, makes for imperfect contact between bearing back and bore and causes the following:

1. Normal running clearance is reduced. After a short period of operation, the bearing may close in across the split line until it contacts the journal surface, tending to shear the oil film.

2. Bearings will tend to move slightly in the housing, scuffing the bearing O.D. and rod or housing bore.

3. Bearings will be loose and allow oil to carry dirt in between the bearing back and rod or case bore. Result: localized loading leading to premature bearing failure.

Too much crush distorts the bore because of the excessive pressure used to bring the cap and housing together. This often increases vertical clearance

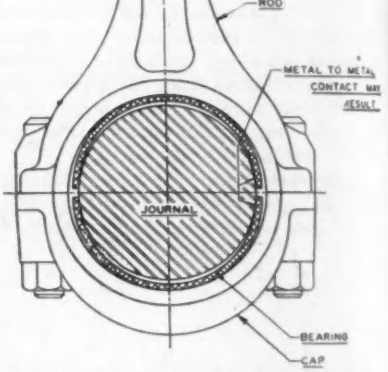


Fig. 2 – Too little crush reduces normal running clearance, causes scuffing and permits dirt in the oil to lodge between the bearing back and bore

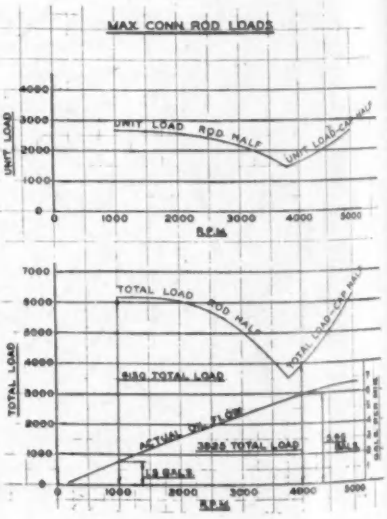


Fig. 3 – These charts show that bearing loads are high at low rpm's – due to high gas pressures and negligible inertia forces – while oil flow during this period is low

Premature Bearing Failure Engine Assembly and Operation

and reduces horizontal clearance so that "wiping" adjacent to the bearing bore split becomes a real danger.

When replacing bearings, it's important that the running clearance be within the tolerances specified by the engine manufacturer. Best method of checking these clearances is to assemble in a case or rod without the shaft and to actually measure the bearing bores under proper bolt torque and crush.

Costly Saving

A strongly condemned practice is filing of the cap, rod end, or block to reduce oil clearance; this supposedly saves on replacement of bearing inserts which have become worn enough to pass too much oil. Although this reduces vertical clearance, it maintains excessive clearance at the sides and may produce an elliptical bore because of the added crush.

Analysis of loading characteristics of a connecting rod bearing for the entire engine speed range will give us an insight to other causes of bearing failure. As shown in Fig. 3, bearing loads at 1000 rpm result from high gas pressure; counteracting inertia forces are relatively small.

With higher speeds the inertia forces increasingly counteract the gas pressures; resultant bearing loads fall off until, at 3750 rpm, the lowest unit bearing pressures are experienced. Inertia forces continue to increase with speed until the load is taken on the cap half.

Note from the curve of pump characteristics that the amount of oil supplied at 1000 rpm is very small – in this case 1½ gal.

Driving a car or truck in high gear when the engine is pulling to its maximum ability results in low engine speed and high gas pressures. Since very little oil is being furnished, there is imminent danger of metal-to-metal contact between bearing and shaft. If the driver operates under this condition too long, this maximum load can cause early fatigue failure.

This problem is especially serious in mountainous sections like Pennsylvania. Many miles of such severe operation can be put on an engine under these conditions.

Temperature is another important factor in bearing operation. Since much of the heat generated by a bearing must be carried away by oil, high oil temperatures can accelerate fatigue, wear, seizure, or corrosion. High temperatures reduce load-carrying capacity of bearing materials – particularly white metals.

High temperature accelerates wear because it reduces oil viscosity which results in decreased oil film strength and thickness.

Corrosion Explained

Corrosion usually takes its toll by removing lead. In copper-lead bearings manufactured with a dendritic structure, shown in Fig. 4, this action leaves unsupported dendrites susceptible to early fatigue failure. Severe corrosion completely eliminates the lead from the bearing surface and leaves pure copper as the bearing material. Here early seizure is a certainty.

Greatest number of bearing failures stems from foreign material in the oil. Excessive shaft wear, fatigue, or seizure are sure to follow. Fig. 5 shows what uninvited dirt can do. Too much care cannot be taken in completely cleaning the engine insides and all components before installing the bearings. (Paper "Present Day Bearings," was presented at SAE Pittsburgh Section, Nov. 26, 1946.)

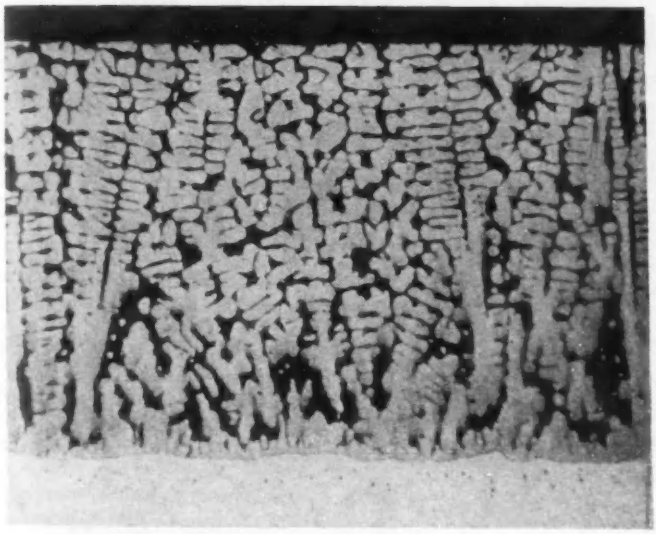


Fig. 4 – Corrosion eats away the lead of copper-lead bearings and leaves this dendritic copper structure which will quickly fail from fatigue

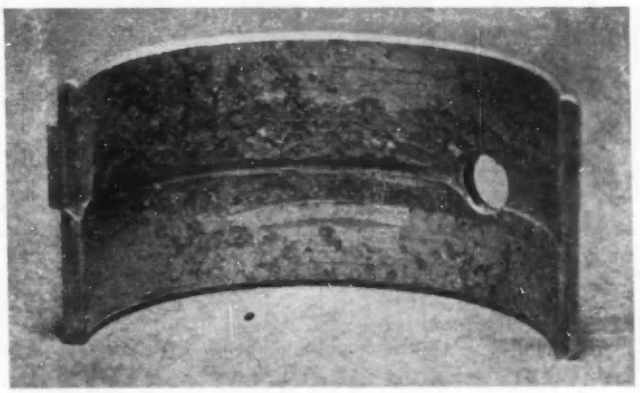


Fig. 5 – That dirt is an enemy of bearings is shown by this havoc wreaked by an accumulation of foreign material

V Shape Reduces Tail Weight, Drag

Digest of paper

By M. J. GORDON

Beech Aircraft Corp.

(This paper will be published in full in SAE Quarterly Transactions)

V-SHAPED tails can be designed which give better results on conventional planes than do conventional tails.

V-tails have been flown on one twin-engine airplane and one single-engine airplane. Fig. 1 shows the V-tail on the Beech Bonanza (Model 35). Design studies have been made on other airplanes. Gordon discusses a number of important design considerations such as elevator power, rudder power, change in trim with extension of wing flap, balance of elevator and rudder forces, and magnitude of dihedral angle.

Advantages of the V-tail over the conventional tail are:

1. There is a reduction in total tail area, with attendant reduction in drag and weight.

2. Intersections are reduced in number to four, with a corresponding reduction in drag.

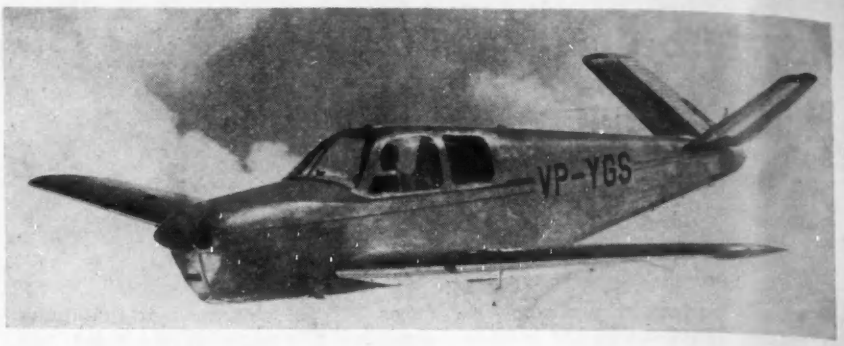


Fig. 1 – Beech Bonanza (Model 35) showing V tail

3. It appears possible to make an airplane that is essentially two-control and spin-resistant and therefore easier and safer to fly.

4. Manufacturing, tooling, and service problems are much simpler because only two major sections are used and no fin or rudder need be considered.

5. Less trim change is required with changes in power; therefore, piloting technique is simpler. (Paper "Development of the Beech V-Tail," presented at SAE National Personal Aircraft Meeting, on May 2, 1947.)

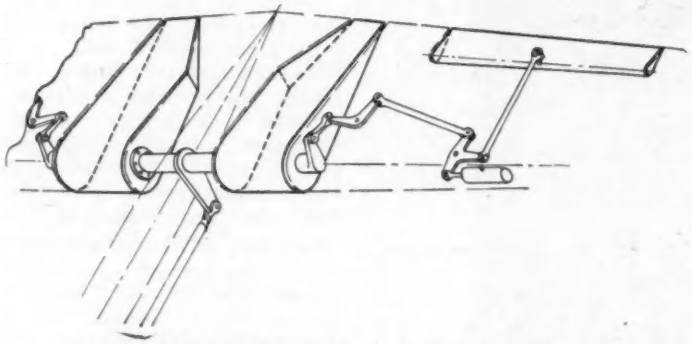


Fig. 2 – Elevator system using feelevator plus spring tab

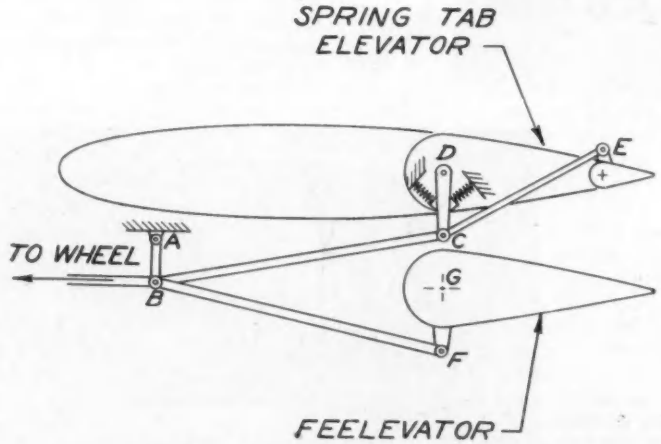


Fig. 3 – Diagram of connections in elevator system

Feelevator Improves Spring-Tab Elevator

Based on paper

By HAROLD O. WENDT

Curtiss-Wright Corp.

(This paper will be published in full in SAE Quarterly Transactions.)

A NEW elevator system for fast fighter planes has been developed to reduce the effect of airspeed on the relationship between stick force and airplane acceleration. The new system uses a set of regular spring-tab elevators plus a set of feeler elevators or "feelevators."

On today's large fighters, elevators without power boost require excessively large stick forces. Spring tabs are used to lower stick forces. But the effectiveness of the spring tab increases with speed, so that the greater the speed, the greater the acceleration for a given stick force. At high speeds, the pilot is able to apply forces to the elevator which impose excessive accelerations on the airplane structure.

Speed has the opposite effect on the feelevator. With increasing speed, the feelevator requires more pilot force for the desired airplane acceleration. The feelevator does not completely counteract the spring tab, but it does reduce the variation with airspeed of total stick force per unit of normal airplane acceleration.

Feelevators can be designed so that at high speeds the highest force the pilot exerts on the stick will not result in dangerously large accelerations. Yet at low speeds, only a reasonable amount of stick force is needed to control the plane.

The new elevator system is shown in Fig. 2. The outer elevators are the conventional spring-tab type, connected together and, through a spring, to the pilot's control column. The spring tabs are connected directly to the pilot's control column so that any deflection of the spring results in relative motion between the elevator and the spring tab. This relative motion of the tab is in the direction such that the

turn to p. 96

TECHNICAL COMMITTEE PROGRESS

New Publication Guide To H-Band Steel Use

Joint SAE-AISI issuance of the new publication "Hardenability of Alloy Steels," is looked to as a much-needed stimulant to accelerate the swingover to the hardenability-band specification method of steel buying by offering new H-bands for broader applications. It marks another milestone in the SAE Iron & Steel Technical Committee's active record of bringing closer understanding between engineer and metallurgist, user and producer.

This one booklet comprises a complete package of information for designing, testing, and ordering H-band steels. It provides the engineer with all the tools he needs to find the most economical and functionally suitable steel for a part. (How and why hardenability bands make this possible are discussed on p. 17 of this issue, in the article "H-Band Method Tailors Steel to Part Function.")

Highlight of this four-part publication is the section containing 62 tentative hardenability bands, 25 of which are being published for the first time. The steels included in this section are as follows:

1320H	4145H	8617H	8660H
1330H	4147H	8620H	8720H
1335H	4150H	8622H	8735H
1340H	4317H	8625H	8740H
2512H	4320H	8627H	8742H
	4340H	8630H	8745H
2515H	4620H	8632H	8747H
2517H	4640H	8635H	8750H
3310H	4812H	8637H	9260H
3316H	4815H	8640H	9261H
4130H	4817H	8641H	
4132H	4820H	8642H	9262H
4135H	5140H	8645H	9437H
4137H	5145H	8647H	9440H
4140H	5150H	8650H	9442H
4142H	6150H	8655H	9445H

With these H-bands is given a complete set of

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J. C. Zeder

instructions on how the buyer should order "H" steels from the mill to get a steel with the desired physicals.

Another important segment of the new publication is the paper "Selection of Automotive Steels on the Basis of Hardenability," by A. L. Boeghold, of GMC Research Laboratories Division. This paper, which has become the classic in hardenability literature, serves as a basic reference for engineers and metallurgists alike.

It explains the advantages of the H-band over the chemical composition method of specification; the hardenability theory; and the method of selecting the proper steel for any given part.

Third section in this pamphlet is the SAE Method of Determining Hardenability. It details equipment and procedure used in performing the standard end-quench hardenability test developed by Boeghold and Jominy.

The fourth section contains a group of six tables on conversion of steel hardness numbers for the various systems.

"Hardenability of Alloy Steels" is now available through the SAE Special Publications Department. The price is $1.00 to members and $2.00 to non-members.

Specs Under Way For Plane Heater

SPECIFICATIONS emphasizing safety and minimum performance requirements of aircraft internal combustion type heaters are being sped toward completion by SAE Committee A-9, Aircraft Air Conditioning Equipment.

Designated Aeronautical Recommended Practice 143A, this report is being brought up-to-date at the request of the Aircraft Industries Association to fulfill a CAA recommendation that an industry specification be developed which CAA can refer to in its Technical Standard Orders for civil aircraft.

ARP 143A will cover not only safety from fire hazard with internal combustion heaters, but also safety from an anti-icing standpoint. Adequate performance of heaters used for heating wing and tail surfaces is definitely contiguous with flying safety. J. W. Ashby, Surface Combustion Corp., and R. A. Kepner, Stewart-Warner Corp., are handling this project and coordinating it with both the industry and CAA personnel.

Slated for future consideration is a recommended practice on internal combustion heater applications, according to Committee Chairman W. W. Reaser, Douglas Aircraft Corp.

Other reports in process and the members handling each are:

1. AIR – Airplane Air Conditioning Engineering Data; M. Tribus, University of California.

2. ARP 367 – Airplane Cabin Supercharging Equipment; F. D. Enfield, Pan American World Airways, Inc.

3. ARP 85B – General Requirements for Airplane Heating and Ventilating Equipment; P. C. Scofield, Airsearch Mfg. Co.

4. ARP 86A – Heater, Airplane Exhaust Hot Air Type; H. Schmidt, Consolidated-Vultee Aircraft Corp., and R. A. Kepner.

5. ARP 89A – Temperature Control Equipment, Automatic Airplane Cabin; T. K. Greenlee, Barber-Colman Co.

6. ARP 147A – Nomenclature, Airplane Air Conditioning; P. C. Scofield.

Modernize Practice On Fleet Maintenance

AN up-to-date Recommended Practice on Preventive Maintenance and Inspection Procedure, prepared by the SAE T & M Technical Committee, has received Technical Board approval for inclusion in the 1948 SAE Handbook. Modification of a wartime report developed for the Office of Defense Transportation, this recommended practice is designed to help the fleet operator establish a preventive maintenance program suited to his individual needs.

It lays down a broad, flexible schedule for periodic inspection and maintenance of all kinds of automotive vehicles. Set up in simple tabular form, it breaks down the maintenance and inspection service according to:

1. Type of Vehicle and Operation: Included are passenger cars, light and heavy trucks, and small and large buses.

2. Type and Maintenance Service: There are five types, designated in terms of mileage range. They are:

a. Daily service noted by driver or garage man when the vehicle enters or leaves the garage.

b. Lubrication service.

c. Heavy or physical inspection with repairs, most adjustments, and tests.

d. Extensive repairs such as replacement of piston rings, engine bearing adjustment, and heavy unit replacement.

e. Comprehensive vehicle overhauls.

3. Itemized Procedure by Parts: The 15 groups covered are: front axle; rear axle; body and cab; brake system; clutch; cooling system; electrical system; engine; frame springs and mounting; fuel and exhaust system; special equipment; steering; transmission; propeller shaft; wheels, rims, and tires.

This effort provides an index to "what" to do and approximately "when" to do it. For example, it tells an operator of heavy trucks on long-haul service that, between 4000 and 6000 miles, his distributors should be lubricated, adjusted, tested, or repaired, if need be.

The Committee points out that the procedures outlined will not satisfy any one set of operating conditions. Each operator will encounter conditions peculiar to his operation and must adapt his preventive maintenance schedule to suit these needs. The truck engaged in city package delivery operates under entirely different conditions than an intercity truck operating between Philadelphia and St. Louis.

Despite the differences between various types of commercial vehicle operation, each fleet operator can use the SAE Recommended Practice as a starting point in initiating a preventive maintenance program. It should help him strike a balance between the two extremes in fleet operators who both entail excessive maintenance costs – the one who inspects too infrequently and experiences costly breakdowns, and the other who spends too much time on inspection and also finds his maintenance bill out-of-line.

The present recommendation is based on a report prepared for the Office of Defense Transportation in 1943 and includes modifications arising from additional experience since that time. The original project was undertaken in the interest of conserving equipment during the war. Frequent requests for the ODT report and numerous references made to it convinced the SAE T & M Technical Committee of the advisability of bringing it up-to-date for inclusion in the SAE Handbook.

ERRATUM

SAE Handbook

There is an error in one of the tolerances shown on the drawing of the Sealed Beam headlamp unit on page 101 of the 1947 SAE Handbook.

On the drawing of the rear view of the unit a tolerance of $\pm$ 0.020 in. is shown on the 0.333 in. dimension for the distance from the center line to the outer surface of the connector lug for the lower beam. This tolerance should be $\pm$ 0.020 in.

Look to Process Control as Key To Expanded Shot Peening Usage

SAE Shot Peening Group Studies New Machines. Chairman J. O. Almen, GMC Research Laboratories Division (seventh from left in the front row), is surrounded by his Committee at its recent meeting at French Lick, Ind.

The machines shown are, from left to right, Newark End Shake Test Machine (for screening); Pangborn Shot Break-Down Tester; Steelblast Vibrating Separator; scales for weighing samples; Almen peening intensity measuring equipment (in front of scales); Mattson Shot Classifier (for measuring size); American Wheelabrator Shot Break-Down Tester; and W. S. Tyler Ro-Tap Test Machine (for screening).

METHODS and equipment offering less uncertainty and more control over the shot peening process headed agenda of the SAE Shot Peening Committee's two-day meeting at French Lick, Ind.

Chairman J. O. Almen, GMC Research Laboratories Division, stressed the strong potentialities shot peening has as a metal-treating process to improve fatigue life. But like heat-treating, best results can be expected only with process control. And shot peening acceptability depends on how well the operation can be controlled.

Emphasis was given to determination of shot characteristics before the blasting operation and elimination of pellets during the process that undergo physical changes. Recently-developed devices that perform these functions, shown in the photograph above, were demonstrated at the meeting.

Concern has been expressed over pellet breakage since fractured shot is ineffective; if recirculated, it might even damage finely finished surfaces. The problem here is to know or to determine in advance how long shot can be used before it breaks. Shot quality has been studied by a group under N. S. Mosher, Chevrolet Division, GMC.

Breakage Resistance Testers

Shown and operated at the meeting were two shot break-down testers that evaluate performance of shot in production blasting equipment. After two years of development, both machines are now ready for laboratory use or for production materials inspection. With steel, rather than cast-iron, shot becoming commercially available, machines of this type will be useful for checking the new materials.

One machine was built by the American Wheelabrator and Equipment Corp. and the other by the Pangborn Corp. Both operate on the same principle.

A slinger wheel accelerates the particles. Leaving the wheel rim with considerable speed, the particles strike targets. This impact subjects the shot particles to the rigors of a regular blasting operation. The machine continuously recirculates the shot sample, exposing it to repeated impacts and progressively removing the broken particles.

The number of passes through the machine at which 55% of the particles are broken represents the life or quality of the shot. On this basis, different shot can be compared.

Another process control is shot peening intensity. Chairman Almen devised an apparatus that measures shot peening intensity and demonstrated it at the meeting.

The Committee also finds that it's important for the shot to be round. Irregular-shaped particles are not as effective as round ones. A machine perfected by the Steelblast Abrasives Co. separates the irregular from the round shot by means of a vibrating table surface, slightly inclined to the horizontal. Irregularly shaped particles climb the incline and drop off the upper end into a container; round particles roll downhill into a different container.

And each shot peening job requires a certain size shot. There must be little variation in size of shot in the machine blasting the part. R. L. Mattson, GMC Research Laboratories Division, developed a shot classifier for rapid determination of shot size. This simple apparatus gives a visual indication of shot size in less than a minute.

While the equipment examined by the Committee at its French Lick meeting will go a long way toward injecting the elements of predictability and control into shot peening, a more thorough study of these problems is to be made by a new subcommittee, chairmanned by W. L. R. Steele, Eaton Mfg. Co.

Standards Acceptance Widening

Review of the present SAE Shot Peening Standards indicated that they are being well received by industry and that their popularity is growing. But the difficulty of screening shot commercially to the shot peening specifications still appears to be a problem.

Shown in the photograph above are, from left to right in the front row: N. S. Mosher, Chevrolet Division, GMC; J. A. Raleigh, Cleveland Metal Abrasive Co.; W. I. Gladfelter, Pangborn Corp.; O. J. Gartner, Steelblast Abrasives Co.; Chairman Almen; R. L. Mattson, GMC Research Laboratories Division; J. C. Straub, American Wheelabrator and Equipment Corp.; F. J. Holland, Metals Disintegrating Co.; C. E. Jenks, W. S. Tyler Co.; R. J. Stewart, Cleveland Metal Abrasive Co.; and W. L. R. Steele, Eaton Mfg. Co.

In the top row, left-to-right order, are: E. A. Milke, Harrison Abrasives Co.; C. A. Bultman, Pangborn Corp.; R. E. Harvie, Chevrolet Division, GMC; H. E. Hall, Metals Disintegrating Co.; H. Marette, National Metal Abrasives Co.; W. L. Kann, Pittsburgh Crushed Steel Co.; M. Z. Delp, Studebaker Corp.; and H. Miller, Buick Motor Division, GMC.

Ignition Group Finds Resistors No Hindrance to Engine Starting

A. L. Beall, Chairman
Ignition Research Committee

PRELIMINARY studies by the SAE Ignition Research Committee show that resistors on spark plugs and distributors of ground vehicle engines – to curb electrical system interference with television and high-frequency radio reception – detract little from the engine's starting ability in cold weather.

Work of the SAE-RMA (Radio Manufacturers Association) Vehicle Radio Interference Committee showed that vehicle electrical system interference with high-frequency entertainment radio and television can be effectively limited with 10,000-ohm resistors on spark plugs and distributor. These recommendations were submitted to the Automobile Manufacturers Association. (See story on pp. 83, 84, SAE Journal, March, 1947.)

While these resistors dampen radio-reception interference emanating from the spark plug, it was thought that they might also reduce the amperage at the plug. This "stealing" of electrical energy would reduce spark effectiveness.

The Ignition Research Committee is investigating the possible deleterious effect of this suppression on cold starting of the engine.

At the last Committee meeting, H. L. Hartzell, Delco-Remy Division, GMC, reported on results of investigations using resistors on seven different engines from cars, trucks, and tractors. He found that five of the seven started quicker without resistors and that four of the seven ran smoother without them. All but one of the engines tested ran at OF.

While these tests were far from complete, Hartzell felt that they seem to indicate that factors more important than resistors influence engine functioning in cold weather. It was the experience of A. W. Pope, Waukesha Motor Co., that resistor effect becomes more apparent with leaner mixtures and with low-volatility fuels.

It was agreed that the Committee would continue this study and would submit data collected to P. J. Kent, Chairman of the SAE Vehicle Radio Interference Committee.

In the aircraft ignition field, Chairman A. L. Beall, Wright Aeronautical Corp., reports that spark-plug testing, development of high temperature-resistant cables, and improvement of terminal designs are among the more important of his group's projects.

Plan New Plug Tests

A subcommittee under E. P. Kovac, American Airlines, Inc., is preparing two comprehensive test procedures – one for plug inspection prior to reconditioning and the other for new and reconditioned plugs. The present SAE Aeronautical Recommended Practice No. 159, Quench Bomb Spark-Plug Test, is considered inadequate for this purpose.

This group has set as a criterion for the ideal ignition analyzer one that can be used in an overhaul shop or by a manufacturer for the following purposes:

1. To locate mechanical failures such as cracked barrels and core insulations;

2. To detect failures such as insulation punctures, fractured center electrodes, and voltage break-downs and troubles due to presence of lead compounds and carbon on the core noses.

They are also looking for a tester that will check out plugs failing because of moisture and corona, a not uncommon condition.

Will Evaluate Testers

It is felt that with further development and improvement, testers now available can do a satisfactory job. To compare several proposed testers, the subcommittee plans to use several defective plugs as standards. They will be numbered and the cause of failure will be unknown to the operator subjecting the plugs to the test.

The progressively upward climb of engine temperatures is responsible for the Committee's effort to develop high temperature-resistant high and low-tension cable. Present cable can withstand temperatures in the order of 360F. Some engine manufacturers note that temperatures as high as 1000F might be encountered in coming powerplants.

Cable manufacturers are investigating ceramics, polyfluoroethylene compounds, silicone rubbers, and fibre glass for such cables. Chairman Beall says that these materials will be looked into by the Committee.

Magnetic Plug Terminal

The search for better terminal designs uncovered, in Committee discussion, a magnetic type of coupling that is claimed to be simpler, lighter, and easier to keep clean than present types. With 100% contact, it takes about a 30-lb pull to remove the connector.

It was pointed out that the built-in magnet in this coupling will pick up any metallic chips present. Some members considered this a desirable feature since all chips would be found in one place and could be easily cleaned. Others felt that magnetic attraction of metallic chips might cause trouble.

Initial flight experience, according to T. Tognola, Scintilla Magneto Division, Bendix Aviation Corp., showed the magnetic connectors to have good radio shielding qualities – especially at high frequencies. Samples of this connector are being sent to various engine manufacturers for further testing.

Flame Arrester Nears Specifications Stage

THE SAE Spark and Flame Arrester Committee has progressed far enough with the project of functional requirements of a spark and flame arrester for internal combustion engines —for use in places such as forests, fields, mines, airports and warehouses —to prepare the preliminary draft of a specification.

Individual members of the Committee have presented their own views with regard to the specification requirements. These are now being reviewed by a subcommittee that is expected to present its consolidated recommendations at the September Committee meeting in Milwaukee.

Chairman W. W. Lowther says that reports of tests being run at the University of Idaho for foresters and lumber interests of the Northwest have been received and show interesting progress from that source.

Close contact is also being maintained with the University of Kansas where work is being done on the same subject for the Army Quartermaster Corps. The AAF Air Materiel Command at Wright Field has also com-

municated with Committee members relative to inaugurating a series of tests on ground powerplants, operated both in the vicinity of aircraft which have just been refueled and in other locations where fuel vapors are present.

Factors that must be considered by the Committee in its spark and flame arrester recommendations include flame arresting efficiency; spark arresting efficiency; back pressure; power loss; silencing; fuel economy; service requirements, and installation.

Seek Uniform Brake Design and Testing

THE SAE Brake Technical Committee and its five subcommittees are progressing toward some degree of uniformity in the testing and inspection of brakes and in certain phases of brake design, according to T. P. Chase, General Motors Research, and general chairman of the Committee.

Chairman Chase reports that the subcommittee on brake linings, headed by T. E. Allen, Thermoid Co., should have its recommended standards—covering drum diameters, lining area, lining widths, thicknesses, and rivet-hole spacing for the 8, 9, 10, 11, and 12-in. diameter passenger car brakes—ready to submit to the SAE Technical Board for final approval sometime this fall.

Before tackling the more complex problem of truck drum sizes and truck linings, the subcommittee decided to proceed first with the simpler problem of passenger car linings and drums.

Agree on Nomenclature

From preliminary discussions of the problem, the subcommittee has agreed that the 13, 14, and 15-in. truck drums and linings should be divided into two groups: (1) those with linings less than ½ in. thick, which will be designated "segments" and (2), those with linings ½ in. and over in thickness which will be designated "blocks."

Another subcommittee headed by S. G. Tilden, of S. G. Tilden, Inc., hopes to develop some rather simple method of accurately measuring stopping distances of vehicles that can be used by law enforcement officers generally.

This group is of the opinion that the only known accurate methods of measuring stopping distances are by the use of guns, which mechanically measure the distance from an accurately-determined initial speed, or by a fifth wheel apparatus that measures and records the stopping distance. However,

cont. on p. 94

SAE Automotive Drafting Manual Propelled as Tech Board Project

Belief that a pressing need exists for bringing uniformity into current automotive drafting practice induced the SAE Technical Board to undertake preparation of a SAE standard automotive drafting manual. It is expected to benefit greatly not only vehicle manufacturers, but hundreds of suppliers and accessory manufacturers as well.

The need for uniform drafting practice was felt most keenly during the war when there was such a complete interlocking of engineering and production technique throughout industry and with various branches of the military. How well a uniform practice of this kind can work was demonstrated by the SAE Aeronautical Drafting Manual. This manual is serving as a guide in the development of the new manual, which will cover the needs of the passenger car, truck, bus, engine, tractor, body, equipment, electrical and accessory industries. All other available manuals are also being studied.

So interested have a number of automotive companies become in the efforts of the SAE Committee in this new project that they have set up drafting manual committees within their own organizations to tie in with the SAE Committee. These company groups will reconcile the nonuniformity of their own divisional and departmental practices so as to present to the SAE Committee the crystallized thinking of the company as a whole.

It is anticipated that the automotive industry may be called on at some future date to participate in a broader unification of drafting practice on a national level. It is believed that the automotive industry will have reached accord by that time through the medium of the drafting room manual, now being developed under SAE auspices.

The SAE Automotive Drafting Manual will not be a design manual or handbook, although it's entirely within the province of the Committee to recommend to the Technical Board the inclusion of any standard tables thought to be essential to a complete and comprehensive manual on the subject.

Another advantage seen in the development and adoption of a uniform practice is the use of such a manual in engineering colleges so that engineering graduates would be familiar with industrial practices when they get into industry.

Technical Board sponsor of the project is D. G. Roos, Willys-Overland Motors, Inc. Chairman of the Steering Committee is W. A. Siler, Delco-Remy Division, GMC, who is also chairman of General Motors' own drafting manual committee. Other members of the carefully-chosen Steering Committee, who head the 15 subcommittees that will do the actual work of preparing the manual, are: W. L. Barth, General Motors Corp.; N. L. Bean, Ford Motor Co.; C. F. Britton, Bendix Products Division, Bendix Aviation Corp.; R. S. Kellogg, Packard Motor Car Co.; F. G. Kerby, The Budd Co.; H. D. MacDonald, International Harvester Co.; H. A. Marchant, Chrysler Corp.; G. L. McCain, Chrysler Corp.; and F. L. Mills, Willys-Overland Motors, Inc. At least two other members will be added to the Steering Committee.

REBER C. STUPP of Dayton, Ohio was recently elected vice-president in charge of production and a director of Jack & Heintz Precision Industries, Inc., Maple Heights, Ohio. He had been with the Delco Products Division of General Motors Corp. since 1922 and for the past four years has been plants manager in three Dayton and two Cincinnati plants.

STANLEY R. SHATTO has been elected vice-president of maintenance and engineering of Western Air Lines. He will have his headquarters in their Los Angeles office. Shatto recently resigned as vice-president of maintenance and engineering of Continental Air Lines, Denver.

CHARLES D. McCALL has been made manager of automotive sales at the New Departure Division of General Motors Corp., with offices in Detroit. His previous connection was sales engineer for the New Departure Division. McCall has been very active in Detroit Section activities for the past several years.

HOWARD L. GINAVEN has been appointed general superintendent of Goodyear Tire & Rubber Co.'s plant in Wolverhampton, England. He joined Goodyear in 1934, starting on the production training squadron. He has been on the foreign operations staff of Goodyear since 1944.

RALPH A. VAIL, who has been an SAE member since 1910, is retiring as vice-president in charge of manufacturing at the Studebaker Corp., South Bend, Ind. In the past, Vail has worked in engineering and production capacities for Oldsmobile, and Franklin, and became works manager of Dodge Bros. before the Chrysler era. He joined Studebaker in 1931.

WILLIAM J. GORMAN, JR. is now sales engineer for the Eclipse Machine Division of Bendix Aviation Corp., Detroit. He had been enrolled at the General Motors Institute.

No longer a designing engineer for the Packard Motor Car Co., Aircraft Powerplant Division, **EUGENE S. CLARK** has become connected with the Menasco Mfg. Co. in Burbank, Calif.

No longer assistant works manager with the Steel Co. of Canada, Toronto, **FRANK H. VERCOE** is affiliated with G. R. Marshall & Co., Ltd., also Toronto.

After graduating from Rensselaer Polytechnic Institute in Troy, N. Y., **ERIC DOORLY** has accepted a position with General Electric Co. in Schenectady, N. Y.

Management changes at Northrop Aircraft, Inc., Hawthorne, Calif., were announced recently by **JOHN K. NORTHROP,** president. SAE members involved are: **RICHARD W. MILLAR,** formerly vice-chairman of the board of directors, and now board chairman, and **B. G. REED,** who will become assistant general manager. He was vice-president in charge of manufacturing.

About

WILLIAM W. REED, who started with the Socony-Vacuum Oil Co., Inc., in 1922 as a chemist in the marketing department at Milwaukee, has been appointed superintendent of the firm's refinery in East Chicago.

Of eight prominent New York University's Engineering College alumni written about in the May issue of the "N. Y. U. Quadrangle," six are SAE members. They are: **RICHARD M. MOCK, WELLWOOD E. BEALL, C. E. PAPPAS, JEROME LEDERER, FRANK N. PIASECKI** and **PROF. LESLIE R. PARKINSON.**

No longer an engineering test pilot with Curtiss Propeller Division, Caldwell, N. J., **WILLIAM A. GARDNER** has become a draftsman at Stearns Roger in Denver.

WILLIAM H. NAHM has been appointed layout draftsman for the Airtemp Division of Chrysler Corp. in Dayton. Previous to this, he was a designer at the Aero Supply Mfg. Co., same city.

ANDERSON GORDON BARTLETT has become general agent for the Sinclair Refining Co. in Milwaukee. His duties will include the supervision of operations and sales management of the Milwaukee area. He had been affiliated with the Emerson Oil Co. in Waukesha, Wis.

GORDON L. RICE has accepted the post of sales engineer for the Bristol Co. in Waterbury, Conn. He had been a metallurgical engineer at the Nelson Specialty Welding Equipment Corp. in San Leandro, Calif.

Heretofore a design engineer at Sherman Products, Inc., Watertown, Wis., **BERTIL T. ANDREN** recently became senior project engineer in the Lincoln-Mercury Experimental Section of the Ford Motor Co., Dearborn, Mich.

Before joining the Pennsylvania Water & Power Co., Baltimore, Md. as a mechanical designing draftsman, **RICHARD G. BURTON** was senior draftsman for the Glenn L. Martin Co., also in Baltimore.

Members

PAUL V. KEYSER, JR., who had been director of the Research & Development Department of Socony-Vacuum Oil Co. Laboratories at Paulsboro, N. J., has been made manager of Socony-Vacuum's Lubricating Oil Department. He is author of several SAE papers and is active on CRC technical work.

Paul V. Keyser, Jr.

Miller Wins Manly Medal

CEARCY D. MILLER, who recently joined the Fuels Technology Division of Battelle Memorial Institute, Columbus, will be awarded the 1946 Manly Memorial Medal at the SAE Aeronautic (Autumn) Meeting on Oct. 3 in Los Angeles.

An engineer with the National Advisory Committee for Aeronautics for the past 11 years, Miller won the distinction for his paper "The Roles of Detonation Waves and Autoignition in Spark-Ignition Engine Knock as Shown by Photographs Taken at 40,000 and 200,000 Frames Per Second," presented at the SAE 1946 Summer Meeting and repeated before seven SAE Sections.

He will continue in research on automotive fuels for which work he designed the high-speed motion picture camera that took the photographs used as the basis of his winning paper. This was published in full in the January, 1947, issue of the SAE Quarterly Transactions.

T. A. BOYD has been elected president of the American Society for Testing Materials. He is head of the Fuel Department, Research Laboratories Division, General Motors Corp. Boyd has presented quite a few papers before the SAE. With **C. F. KETTERING** and the late **THOMAS MIDGLEY,** he discovered the antiknock effects of the liquid compounds of lead.

J. G. MORROW, metallurgical engineer of the Steel Co. of Canada, Ltd., Hamilton, Ontario, has been elected vice-president of the ASTM. He will serve for a term of two years.

Now employed by the Vendo Co., Kansas City, Mo. as a manufacturing engineer in the Plant Engineering Department, **THOMAS M. WELLS** has been associated with Lockheed Aircraft Corp., Burbank, Calif.

Graduating recently from Ohio State University, **PAUL E. MORGAN** is now employed by the Westinghouse Electric Supply Co. in Columbus, Ohio.

CHARLES A. DEVINE, JR., is now manager at Theo. H. Davies & Co., Ltd., Hilo, Hawaii. He is secretary and treasurer of the Hilo Division, Hawaii Section, for 1947-48.

Among a list of notables recently honored by Princeton University, at the climax of their 200th anniversary celebration, were **CHARLES F. KETTERING,** consultant and member of the board of General Motors Corp. and recently retired as general manager of General Motors' Research Laboratories, and **ALFRED P. SLOAN, JR.,** chairman of the board and past president of the corporation. They received an honorary degree of Doctor of Laws.

Preceding his appointment as head of the Mechanical Engineering Department at North Carolina State College, Raleigh, N. C., **KARL P. HANSON** was professor of mechanical engineering, University of Connecticut, Storrs, Conn.

Previously at Yale University, **EDWIN J. FARRELL** is now an automotive engineer with the Standard Oil Co. (Ind.), Whiting, Ind.

Now a salesman of motor products, Goetz Oil Corp., Tonawanda, N. Y., **WILLIAM H. ELGAR** held a similar position with the Sun Oil Co. in Kenmore, N. Y.

Now a director of the Motor Coach Division of Ford Motor Co. in Dearborn, Mich., **WILLIAM B. LIVINGSTON** had been affiliated with the General Motors Truck & Coach Division, Pontiac, Mich.

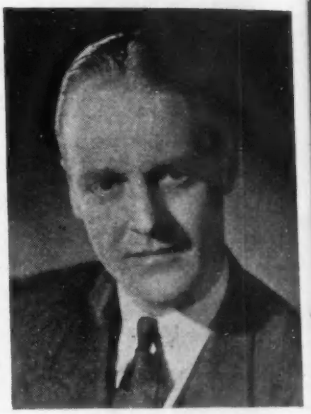
CATERPILLAR PROMOTIONS

J. M. DAVIES (left) has become associate director of research in administrative charge of the Research Department of Caterpillar Tractor Co. under C. G. A. ROSEN, director of research. He was formerly assistant director of research. R. C. WILLIAMS (right) assumes Davies' former position and is also assistant director of research in charge of tractor and earth moving research projects

SAE Fathers and Sons . . . . .

CARL BREER, director of research, Chrysler Corp., Detroit and his son, **C. FRED BREER,** who recently was appointed sales manager of McCulloch Motors Corp., Los Angeles. The elder Breer has been a member of the SAE since 1920.

President of the Borg-Warner Corp. in Chicago, **CHARLES S. DAVIS, SR.,** with his son **CHARLES, JR.,** who is vice-president and general manager of the Norge-Heat Division of Borg-Warner in Detroit. The father has been an SAE member since 1936.



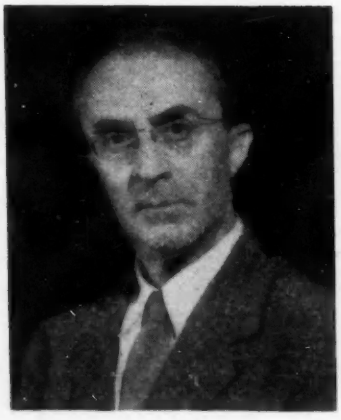
If any SAE reader knows of any SAE Father-and-Son combinations both of whom are members of the Society, your editors would appreciate hearing from you. Several SAE members have two Member-Sons.

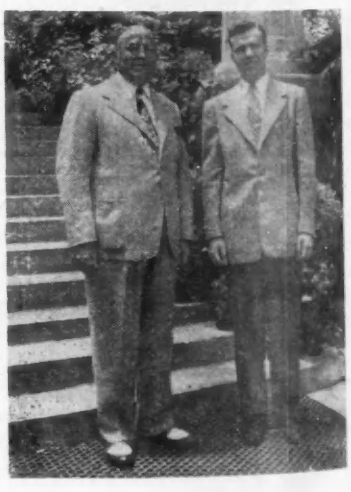
We will write for photographs, Informal pictures of such combinations are preferred to individual formal portraits.

Your cooperation will be deeply appreciated – we don't want to miss any SAE Father and Son grouping.

PAUL H. OBERREUTTER, president and dynamometer engineer, since 1922, of the Mid-West Dynamometer & Engineering Co., of Chicago, and his son, **PAUL W. A.,** electrical engineer for the same company. Paul H. is treasurer of the Chicago Section and has been active in the Society since 1935.

SPYRO KYROPOULOS, M '45, is affiliated with California Institute of Technology, Pasadena. His son, **PETER R.,** is an instructor of mechanical engineering at the above college.





Until recently a research engineer at the Harvey Machine Co., Los Angeles, **ROBERT J. WENTE** is now a liaison engineer with the Allison Division of General Motors in Indianapolis.

RICHARD SODERBERG has been appointed head of the department of mechanical engineering at M.I.T. His appointment will permit **DR. JEROME C. HUNSAKER,** who has been head of both the department of mechanical and aeronautical engineering since 1933, to devote his entire attention to direction of the Institute's rapidly expanding program of research and instruction in aeronautical engineering. Prof. Soderberg has been deputy head of the mechanical engineering department for some time and is already thoroughly familiar with its administration.

The retirement of **BEN H. ANIBAL,** who has directed the engineering development of the Pontiac car since its inception, has been announced. Anibal has been with General Motors 34 years and a chief engineer for 25 years.

P. L. BARTER, vice-president of McCord Corp. for the past 23 years, has been elected to the newly-created office of vice-chairman of the board of directors. He will continue to hold his present post as vice-president.

No longer connected with the Menasco Mfg. Co. in Burbank, Calif., as a gage designer, **J. C. ARMELING** has become an inspector with the Axelson Mfg. Co. in Vernon, Calif.

ELMER W. BERNITT recently became corporation general plant engineer for the Nash-Kelvinator Corp. in Detroit. He had been plant engineer for Nash Motors Division of this company in Kenosha, Wis.

LEWIS M. TOWNSEND has resigned his post as service representative with Wright Aeronautical Corp. in Wood-Ridge, N. J., with the idea of starting his own business.

LESTER D. GARDER of New York has been awarded the 1947 Daniel Guggenheim Medal for notable achievements in the advancement of aeronautics, particularly for his organization of the Institute of the Aeronautical Sciences. This was organized in 1932. He was chairman of its council and president of the Aeronautical Archives until his retirement this year.

PEYTON M. MAGRUDER has announced the formation of Aeronautical Consultants Inc. They will have offices in New York City and Washington, D. C. Magruder was chief of New Design during the war for the Glenn L. Martin Co., and until recently director of commercial sales for that firm. He was the designer of the famous B-26 Marauder and other outstanding Martin aircraft.

JOHN MARTIN CLARK, JR., is now chief designer and owner of John Clark, Engineers and Designers in San Antonio, Tex. They will specialize in machine and tool design, product redesign and styling, and maintain a complete patent service for inventors. Prior to this he was a powerplant engineer at the Douglas Aircraft Co., Santa Monica, Calif.

ALLEN T. WELCH, veteran Pacific Northwest bakery engineer, has announced the establishment of the Allen Welch Bakery Engineering Service with headquarters in Portland, Ore. In the past he has been connected with the Davidson Baking Co., Portland, and the Ford Motor Co. Welch is past secretary of the Oregon Section.

BERTON H. DELONG has been appointed to the office of vice-president and technical director at the Carpenter Steel Co., Reading, Pa. He has been with Carpenter since 1910, and before his recent promotion, held the office of vice-president and chief metallurgist.

FRED M. ZEDER, vice-president in charge of engineering of Chrysler Corp., announced the retirement of **OLIVER H. CLARK,** executive engineer, after 22 years of engineering work with the company. He was appointed to his present position in 1935.

JAMES A. HAND is now division maintenance superintendent with the CNRRA Highway Transport in Shanghai, China. He is responsible for all maintenance in Shanghai, Nanking, Wuhu, Hangchow and Nanchang. Below left is the lubrication ramp in Shanghai, showing the office in the extreme rear. At the right, are some trucks loaded with rice for Kiangsi Province.

VICTOR H. SCALES, public relations counsel to the SAE and other organizations, has received the decoration, Knight of the Order of Orange-Nassau, from Queen Wilhelmina of The Netherlands for wartime and postwar services to the Dutch people through the Queen Wilhelmina Fund, American Relief for Holland, and United Service to Holland, for which he has directed relief operations. On July 9, Scales sailed for Holland on the MV Westerdam.

WALTER C. THEE, who has been a commissioned officer in the U. S. Army since 1917, has applied for retirement with the rank of colonel to enter civilian life. He plans to summer vacation in the New England States.

Heretofore with Pratt & Whitney Aircraft Co. in East Hartford, Conn., **NORMAN B. NEWTON** has taken a similar position with the Hamilton Standard Propellers Division of United Aircraft Corp., same city.

Previously with the Harley Davidson Motor Co., Milwaukee, as an experimental engineer, **HOMER W. MILLER** is now holding a similar position with the Kiekhafer Corp., in the same city.

Now an agent-representative for the Metropolitan Life Insurance Co., Brooklyn, N. Y., **ALFRED J. HAFEMEYER** had been territory representative for the Bear Mfg. Co. in Rock Island, Ill.

WALTER R. WYKOFF has been appointed research engineer at Battelle Memorial Institute, Columbus, Ohio. Previous to that post he was a project engineer at Pratt & Whitney Aircraft Corp., East Hartford, Conn.

Prior to becoming an electrical engineer with the War Department Chemical Corp., Frederick, Md., **NELSON E. ALEXANDER** was an instruments engineer for the Dugway Proving Ground, Tooele, Utah.

Recently a student at the University of Wisconsin, **WILLIAM O. TRUEBLOOD** is now employed as an industrial engineer with the Proctor & Gamble Co. in Cincinnati.

HARRY T. WOOLSON is now officing with the Mont Wickham Associates, Detroit, but is not one of the associates. He is acting in an engineering consultant capacity for them, and he is free to consult on any special engineering problems.

The resignation of **H. L. KNUDSEN** as vice-president of engineering has been accepted by the Cummins Engine Co., Inc., Columbus, Ind. He had been associated with the company and its predecessors for more than 25 years. Knudsen will continue as a director of the company, and also will serve as engineering consultant on problems of design and research.

Previously a graduate student at Cornell University in Ithaca, N. Y., **STUART HAMILTON** is now intermediate engineer for the Cornell Aeronautical Laboratory in Buffalo.

RICHARD H. OWENS, formerly chief project engineer on engine development at Jack & Heintz Precision Industries, Cleveland, Ohio, recently joined the engineering staff of the Power Plant Division at Menasco Mfg. Co., Burbank, Calif. This company is currently engaged in gas turbine development.

Having left the Cross Mfg. Co. of Bath, England, **T. SHERWEN** has joined Harry Ferguson, Ltd., of Coventry as project engineer.

Formerly enrolled at the Case School of Applied Science, **CARL J. ALBERTI** is now a junior partner with the R. J. Bell Co. in Cleveland.

OBITUARIES

T. C. DELAVAL-CROW

Thomas Clive DeLaval-Crow, 61, chief engineer at the New Departure Division of General Motors Corp., Bristol, Conn., died on June 28 after an illness of several months.

He started work as an apprentice with the Electric Tramway Equipment Co. of Birmingham, England and later was a draftsman with Alldays and Onions of Birmingham. He came to this country in 1907 and joined New Departure in 1914. He has been chief engineer since 1921.

Delaval-Crow has been an SAE member since 1921. He was treasurer of the Southern New England section and was a past chairman of the Annular Bearing Engineers Committee.

WILLIAM L. McGRATH

After an illness which had confined him to bed for some time, William L. McGrath, former general manager of the Eclipse Machine Division of the Bendix Aviation Corp., passed away on June 18 in Elmira, N. Y. He was 61 years of age.

McGrath joined the old Eclipse Machine Co. in 1916, as chief engineer. He successfully advanced in executive positions to become president and general manager in 1933. When the Bendix Aviation Corp. acquired Eclipse in 1929, McGrath became a director and corporation vice-president. When Eclipse became an operating division of Bendix in 1938 he also assumed the duties of divisional general manager.

He retired in 1944.

MARTIN E. LEADON

Martin E. Leadon, general superintendent of aircraft maintenance at Northwest Airlines, Inc., St. Paul, Minn., passed away on July 3. He was returning from the Orient on a CAA proving run preliminary to the inauguration of the company's services into that area. He died very suddenly just before the plane landed at Edmonton, Alberta, Canada.

Leadon joined Northwest Airlines in 1929 and was appointed general superintendent of aircraft maintenance five years ago.

A very enthusiastic and energetic supporter of the SAE, both local and national, Leadon was a member of the Air Transport Activity Meetings Committee.

News..

..OF THE SOCIETY

1946 SAE Transactions Includes 17 Extra Papers

1946 SAE Transactions (published early this year and the last of the series of annual volumes) include 17 papers not previously printed in full, as well as the usual reprint of material contained in the monthly Transactions Section which was then part of the SAE Journal for the first nine months of 1946.

These 17 extra papers are printed in full in the 1946 volume of SAE Transactions, and include all the authors' illustrations. They are:

1. "Systematic Approach to Aerodynamic Design of Radial Engine Installations," by F. V. H. Judd, which covers a general method for estimating the airflow through, and the drag of, naturally aspirated radial aircooled engine installations.

2. "Airplane Icing Problem and Its Alleviation through Research," by A. R. Jones, which summarizes the results of research in ice-prevention equipment over the past few years.

3. "White Hydro Torque Drive," by R. Brunken, which describes an extremely flexible type of transmission.

4. "Heat Recovery Applied to Heating and Anti-Icing of Aircraft," by J. J. Draney, which discusses the use of heat recovered from engine exhaust to heat cabins and flight decks, as well as for anti-icing of aerodynamic surfaces and propellers.

5. "Shop Aspects of New High-Strength Aluminum Alloys," by R. A. Miller and M. E. Tatman, which includes the results of a study to determine how best to fabricate aircraft components made of certain aluminum alloys.

6. "Review of Air Transport Developments in America," by R. D. Kelly, which summarizes the important points in the papers sponsored by the SAE Air Transport Activity during 1945.

7. "Factors Relative to Selected Stalling-Speed Regulations for Transport Airplanes," by M. F. Vanik, which discusses the limiting effect of maximum stalling-speed requirements on efficient design of high-speed transport airplanes.

8. "Effect of Octane Number and Volatility of Fuels on Horsepower and Fuel Economy of Tractor Engines," by W. G. Ainsley and W. F. Strehlow, which defines light- and regular-grade tractor fuel in terms of distillation characteristics and octane number.

9. "Planning Cabin Interiors for Transport Aircraft," by W. Prokosch, which discusses various factors in cabin design in their relation to the governing consideration of types of service to be offered.

10. "Safety in Airline Operation," by J. Lederer, which discusses discrepancies in present design, equipment, procedures, and mental attitudes, and suggests improvements for overcoming them.

11. "Evolution of New 'Work Horse' Airplane for Airline Use," by M. B. Bassett, which covers the factors involved in the design of a new medium-range commercial airplane.

12. "Design and Test Experience with Monocoque Magnesium Wings," by J. C. Mathes and E. Rottmayer, which discusses the development of a monocoque magnesium wing.

13. "Air Transport Selection," by L. H. Allen and J. G. Borger, which presents the numerous factors that an airline must consider in choosing a new type of transport airplane.

14. "Stability Problems with Swept Wings," by H. A. Soulé, which discusses the structural and stability problems involved in the use of swept-back wings to increase the speeds at which radial flow changes over wings occur.

15. "Emergency Equipment for Overwater Operation," by J. G. Borger and R. O. Jacobson, which discusses the complex operational problems of overwater flights.

16. "Utilization of Exhaust Gas of Aircraft Engines," by B. Pinkel, which analyzes the recovery of energy from the exhaust gas of reciprocating engines by means of exhaust jet, steady-flow turbine, and blowdown turbine, and discusses the performance of reciprocating engines compounded with these energy-recovery devices.

17. "Economics of Airline Fuel Utilization," by W. V. Hanley and A. Hundere, which presents a mathematical analysis of the problem of using high-quality fuel of grades 100/130 and 115/145 in transport airplanes.

July, 1947, marked the thirtieth anniversary of the SAE Journal in its present page size and name. It was known for a time as the Journal of the Society of Automotive Engineers when it appeared as the successor to the SAE Bulletin, published first on April 15, 1911, about six years after the Society was founded.

The Bulletin measured about 6 x 9 in.

Now Available

Copies of 1946 SAE Transactions, bound in cloth, are available from SAE Special Publications Department, Society of Automotive Engineers, Inc., 29 West 39th Street, New York City 18, at $2 to SAE members and $10 to nonmembers.

Olley, Rosen Represent SAE at British Centenary

CELEBRATING its 100th anniversary during the week of June 8, the British Institution of Mechanical Engineers offered a comprehensive program of technical papers. Maurice Olley, Vauxhall Motors, Ltd., and C. G. A. Rosen, director of research, Caterpillar Tractor Co., represented the SAE.

A thanksgiving service on Sunday at Westminster Abbey was addressed by the Dean of Canterbury, and sessions during the week were under the general chairmanship of Lord Dudley Gordon, president of the British organization.

Among the speakers were Prime Minister Attlee; Herbert Morrison, Lord President of the Council; Sir Bracewell Smith, London's Lord Mayor; Sir Robert Robinson, president of the Royal Society; Jonheer ir. O.C.A. van Lidth de Jeude, of the Royal Dutch Institute of Engineers and former Netherlands minister of war; Prof. A. G. Christie, Johns Hopkins University, and past-president of the ASME; Vice-Admiral Sir Harold A. Brown; Sir Ben Lockspeiser; Hon. J. Kenneth Weir; Sir S. Leonard Pearce; Maj. E. J. Buckton; Sir William A. Stanier; Prof. A. Robertson; Sir Frank E. Smith; Sir Claude D. Gibb; F. G. Woollard; Prof. Sir Geoffrey I. Taylor, and Prof. F. C. Lea.

Thirty-eight technical papers were presented, and authors included Harry R. Ricardo; Prof. W. J. King, Cornell; Prof. W. R. Hawthorne, M.I.T.; Prof. J. D. Crockcroft, British atomic expert; Sir Johnstone Wright, general manager, Central Electricity Board; W. H. Carrier, Carrier Corp., Syracuse, and past-president, ASME; L. Armand, director, French National Railways; P. W. Kiefer, New York Central System; Dr. A. H. Rohn, president, Swiss Federal Institute of Technology; Dr. R. E. Doherty, president, Carnegie Institute of Technology; Maurice Platt, Vauxhall Motors, Ltd.; V. W. Pilkington, Leyland Motors, Ltd.; and Prof. Sir Charles E. Inglis, vice-provost, Kings College, Cambridge.

SAE Handbook Data Translated by Chinese

COPIOUS use of material from the SAE Handbook has been made by the Chinese Standards Committee of that nation's Ministry of Economic Affairs in its Series 24 CIS. Subjects covered include flanges, more widely used steels, copper, and aluminum alloys, piston rings and groove dimensions, leaf springs, and other components.

Named to Advise U. S. Agencies on Education

COUNCIL confirmed the appointment of Alwin A. Gloetzner and E. K. Owens, chairman and secretary respectively of the Washington Section, to serve on the Science Training Group of the Advisory Committee on Scientific Personnel.

The committee is composed of representatives of the eight Government agencies which employ the major number of scientific employees.

The major function of its Science Training Group is to determine the need for, and to facilitate and encourage science training of, such employees in the District of Columbia.

It will formulate training programs, in conjunction with schools, colleges, and technical societies, for those who need either undergraduate, graduate, or postgraduate work in the various specialties of engineering and science.

Past-Chairmen Aid Plans

CHAIRMAN Robert Gardner of the New England Section has appointed eight past chairmen to assist the Meetings Committee of which Elty C. Guiou is chairman.

Vice-chairmen of engineering activities will thus have the help and counsel of men who are experienced in SAE administrative work.

ISO Names Secretary

HENRY ST. LEGER has been appointed general secretary of the new International Organization for Standardization (ISO).

An American citizen, St. Leger leaves his post with the U. S. Counsel for the Axis trials at Nuremberg, where he took a major part in organizing those trials.

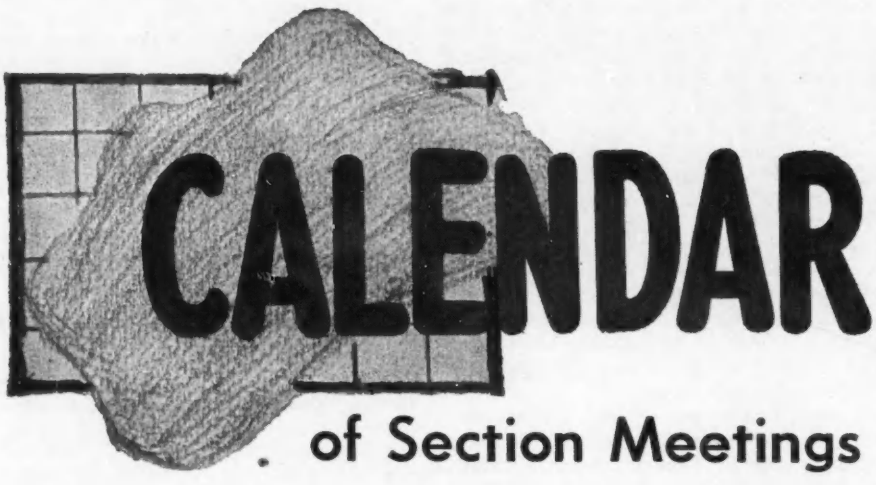
Canada, Chile, and Hungary are new ISO members, bringing the total to 23 countries with national standardizing bodies. Five are in the Western Hemisphere.

Frudden Wins Award

PRESIDENT C. E. Frudden won an award for one of the five best papers presented during the year before meetings of the American Society of Agricultural Engineers at that organization's annual dinner, June 25, at the Benjamin Franklin Hotel, Philadelphia.

The award-winning paper was "Factors Controlling the Rate of Moisture Removal in Barn Hay-Cutting Systems," presented in January, 1946, at Lafayette, Ind.

On the day previous to presentation of the award, he summarized the questions, answers, and discussion following the Power and Machinery program on Taking Stock of Farm Power and Machinery Research.



of Section Meetings

AN extensive tour of SAE Sections in the Western States and Canada will begin on Aug. 7, when SAE President C. E. Frudden will visit and address the Spokane-Intermountain Section at the Desert Hotel in Spokane.

He will be the guest of the Northwest Section at the Edmond Meany Hotel in Seattle the next evening, and will visit the British Columbia Group in Hotel Georgia, Vancouver, Aug. 11. From there he will go to Portland, home of the Oregon Section, where he will address members at Lloyd's Golf Club on Aug. 13, and will head south to San Francisco where he will be entertained by the Northern California Section members at Treasure Island Officers' Club, Aug. 15.

San Diego Section will be his host on Aug. 19 at the Women's Club there. He is due to address the Salt Lake Group on Aug. 25 at Coveys New American Lodge in Salt Lake City, and will close his tour on Aug. 27 at Denver, where he will address the Colorado Group at Mountain Lodge. He will speak on "Engineering 'Whys' of the Modern Tractor," and will illustrate his paper with a motion picture, "Tractors at Work."

Student Branch News

University of Oklahoma

The SAE Student Branch at University of Oklahoma held its last meeting of the spring semester on May 14, when new officers were elected and Art A. Darling, of Cooper-Bessemer Corp., presented a paper on gas-diesel engines.

Gas diesels, Darling said, have found large fields in powerplants and gas sewerage plants using 10% diesel fuel and 90% gas. In testing these machines, it was found that they had a poor fuel consumption at loads less than 75%. This problem was overcome by use of variable control of air throttling with different loads with turbocharger. The engines can be changed to different ratios of diesel fuel to gas, or to full diesel. The timing changes with load.

He presented a film on "Continuous Performance," showing the manufacture and testing of gas diesel engines.

– by Joe D. Burton, Field Editor

Northrop Aeronautical Institute

Northrop Student Branch members made two field trips at their May 29 and June 14 meeting – one to the Vernon Plant of Aluminum Co. of America, the other to the Hermann Engineering Co. at Glendale.

At Alcoa students were introduced to the many steps required to obtain aluminum from the ore by a film called "This Is Aluminum." Then they divided into six sections to make tours of the plant. They saw the extrusion department, the foundry and the die shop, and some groups were able to visit the magnesium fabricating plant and the quality-control laboratory.

At the Hermann Engineering Co., K. L. Hermann, president, demonstrated the operation of the Hermann cam engine and explained how it is manufactured. He showed students how much easier it is to build than the conventional reciprocating engine, because of the fewer parts required. The model run during the inspection was 28 in. long and 12 in. in diameter, yet produced 170 hp. Points of particular interest in the engine were its 12 cylinders arranged parallel to the crankshaft, and the use of a cam to transmit power from the piston to the crankshaft.

– by Leon M. Warne, Field Editor

Oregon State College

Forty members of SAE Oregon Section joined Student Branch members at their May 16 meeting on the Oregon State Campus. Students gave them a demonstration of equipment in the automotive laboratory, and the two groups spent considerable time talking shop before the buffet supper.

The evening session, conducted by Oregon Section Chairman Howard Morse and Technical Chairman Prof. W. H. Paul, was devoted to technical papers presented by student members on current projects being carried on in

SAE National

TRACTOR MEETING

Hotel Schroeder
Milwaukee

September
17-18

Wednesday, September 17

9:30 A. M.

C. G. A. Rosen, Chairman

Butane and Propane as Tractor Fuels – E. A. Jamison, W. F. Swett, J. R. Strother and C. R. Dougherty, Phillips Petroleum Co.

The Elimination of Combustion Knock – E. M. Barber, Texas Co.

1:30 P. M.

Martin Ronning, Chairman

Tractor Speeds for Implement Use Tillage and Planting – H. V. Hansen, J. I. Case Co.

Harvesting Grain, Hay and Corn – Robert Worrell, Allis-Chalmers Mfg. Co.

Capacity Requirements for Power Controlled Agricultural Implements – Stanley Madill and Knud Sorensen, John Deere Tractor Co.

Thursday, September 18

9:30 A. M.

L. A. Gilmer, Chairman

Stationary Axle and Rotating Axle Idler Wheel Mountings Compared for Implement and Tractor Service – George Curtis, Timken Roller Bearing Co.

Maintenance Engineer's View of the Tractor Service Business – Paul Dumas, Implement and Tractor Magazine.

A Practical Approach to Operator's Comfort – C. W. Cannon and Earl Cox, Allis-Chalmers Mfg. Co.

1:30 P. M.

L. S. Pfost, Chairman

Farmall Cub Tractor and Its Implements – C. A. Hubert and J. L. Hipple, International Harvester Co.

DINNER

7 P. M. — Speaker to Be Announced — **Ballroom**

B. G. Van Zee, Chairman

E. M. Schultheis, Toastmaster

SAE President C. E. Frudden

SAE NATIONAL MEETINGS

MEETING	DATE	HOTEL
WEST COAST T&M	Aug. 21-22	Biltmore Los Angeles
TRACTOR	Sept. 17-18	Schroeder Milwaukee
AERONAUTIC (Autumn)	Oct. 2-4	Biltmore Los Angeles
PRODUCTION	Oct. 20-21	Carter Cleveland
FUELS & LUBRICANTS	Nov. 6-7	The Mayo Tulsa
AIR TRANSPORT	Dec. 1-3	Continental Kansas City, Mo.
ANNUAL	Jan. 12-16 (1948)	Book-Cadillac Detroit

the laboratory. Corwin D. McLean, graduate student in mechanical engineering, presented a paper on "Development of a Method for Determination of the Pre-ignition Qualities of a Fuel"; Walter E. Fauerso, senior M.E. student, spoke on "Automotive Possibilities of the Gas Turbine"; and Lester R. Jones, another senior M.E. student, covered "Recent Developments in Water Injection for Automobiles."

Section members commented on the extensive and modern equipment in the College automotive laboratory, considered one of the best on the west coast.

Professor Paul gave a brief resume of the size of the student branch on the campus, and described the work and activities of this organization in conjunction with the course in automotive engineering offered by the school.

– by Chugh Sun, Field Editor, and Edwin J. Schmidt, Secretary-Treasurer

California Institute of Technology

Members of the SAE Branch attended the final meeting of the school year of Caltech Consolidated Engineering Societies, May 23, to hear H. B. Lewis, Los Angeles consulting engineer, talk on the most sorely neglected phase of engineering – handling people. Lewis told of his dismay when he was told in college that engineering is 10% handling things and 90% handling people. Then he went on to show how, by his own experience, he found that statement to have enough truth in it to make it virtually impossible for any aspiring engineer successfully to ignore it.

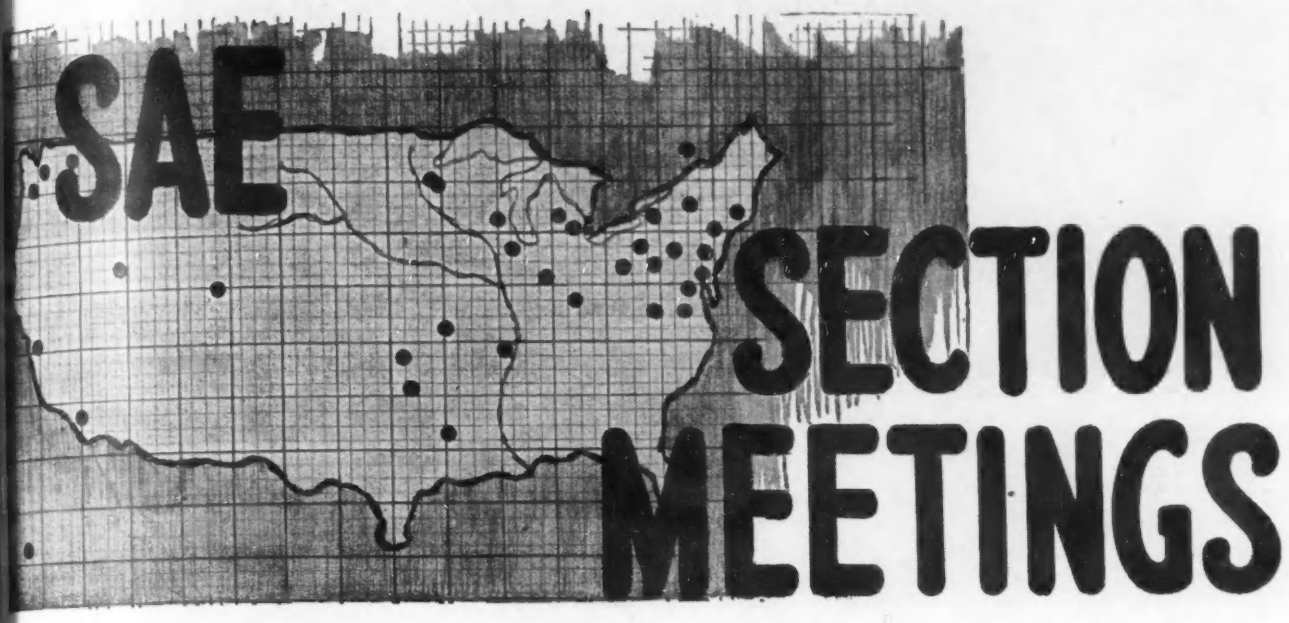
"I don't know whether the 10-90 division is right or wrong," he said, "but I am convinced that there is a great deal of truth in the thought behind it. . . . I realized that . . . management expected to pay 10 to 15% for sales, and was very reluctant to pay one-half of one percent for engineering. Obvious conclusion was to sell instead of engineer. . . .

"The absolute minimum of getting along with people, if you are to achieve the rudiments of success, is to sell yourself to an employer and get along well enough with him and your fellow workers so that the employer stays sold. . . . Nobody is going to hire you for what you know; what business wants is productivity, which means knowledge put to use. . . . Some of you will find yourselves heading organizations large enough to require that almost all problems except selection and general direction of key personnel will be delegated, and some will get into advertising or some type of personnel, industrial relations, or sales work involving practically nothing but personalities and their interrelations.

In our system, sales are the lifeblood of business, and it is the salesman who pumps them through the system; so the salesman may well be called the heart of the business. As I've already said, the engineer must sell himself and his ideas; there is no reason why he shouldn't go further and sell any product or service he or his organization has to offer.

"The one point I want to drive home . . . is this: Don't feel that you are being untrue to yourself if you depart from the engineering field. Your engineering education, far from being wasted, will be a great asset whatever you do."

John M. Heldack, of General Electric Co., answers questions about the I-40 GE turbojet engine for Caltech student Branch members. Heldack spoke on turbojet engines at the group's May 21 meeting



Section Sportlovers Hold Variety Meeting

by A. M. WATSON, Field Editor

SOUTHERN NEW ENGLAND Section, May 16 – Section members took to the outdoors, well supplied with beer, for this meeting. A few of the less energetic chose to forego softball and golf in favor of bridge, but everyone joined in the banquet-sized dinner that followed. An old-fashioned songfest filled in between courses, and a vibraharpist and barber shop quartet supplied after-dinner musical entertainment.

Chairman Ken Thomas introduced E. L. (Skip) Eveleth, of Sikorsky Aircraft, who presented excellent color movies and a lively commentary on the Bermuda Races of 1946, in which he participated as a crew member of the Malabar XIII.

Complete satisfaction of everyone present was enthusiastically expressed by a rising vote of thanks to Dwight R. Judson, who had charge of arrangements for the outing.

New Means and Methods In Transit System Use

by R. W. BIXLER, Field Editor

SOUTHERN CALIFORNIA Section, June 5 – How a large transit system helps solve problems that arise in transporting 394,000,000 passengers for 43,000,000 miles a year with the help of mobile radio and other modern facilities was described at this Truck and Bus Meeting by Cone T. Bass, vice-president and general manager for Los Angeles Transit Lines.

Since LATL took over the transit system from the Los Angeles Railway Co. in 1945, he said, a complete overhaul of rolling stock, buildings, and shop facilities has been in progress. Antiquated equipment is being disposed of as modern replacements are received. More than 300 new motor coaches have been placed in service, and 40 modern trolley coaches will begin their runs as soon as the necessary overhead construction is completed.

LATL now has 625 motor coaches (500 of which are diesel), 750 streetcars, and 40 trolley coaches. Annual power requirements consume 3,000,000 gal of motor fuel, 200,000 quarts of oil, and 96 kw-hr of electricity.

The system is operated by 4500 people. It has its own radio station and has equipped its supervisory personnel-operated cars and trucks with two-way radio in an effort to minimize schedule stoppages due to mechanical failures, accidents, and other causes. All messages and conversation passing through the station are permanently recorded. Besides saving schedule time, this setup also reduces maintenance travel to a minimum since "new" service calls can be transmitted to the crew in the field.

Transit line operation and maintenance are only a present consideration, Bass said. There are also headaches in planning changes and expansions in facilities. It is necessary to keep up with a rapidly increasing and shifting population in a constantly expanding area.

R. W. Cochrane, retiring Southern California Section chairman, introduces Chairman-Elect L. D. Bonham of Lockheed Aircraft Corp. at the Section's Truck & Bus meeting, June 5

Proper division of the $125,000 in prizes distributed to the starters after the 500-mile race on the Indianapolis Motor Speedway, May 30, was handled by this group—three of whom happen to be SAE members. Left to right: Clifford M. Rigsbee, assistant director of timing and scoring, and 1945-1946 chairman of Indiana Section; William S. Powell, chief timer, and 1947-1948 chairman; Ray House, assistant timer, and Chester S. Ricker, director of timing and scoring, Section chairman for 1920-1921. Indiana Section's yearly Race meeting was held May 22, with R. A. Railton speaking on "Odd Problems at High Speeds." Two hundred were present for dinner and the social half hour, and another 125 arrived for the lecture and discussion period, including students, members and professors from Purdue who came 60 miles.

Dynamometer Tests Pay Off in Economy

by J. H. MACPHERSON, Jr., Field Editor

NORTHERN CALIFORNIA Section, June 10 – Errol J. Gay, manager of the Commercial Engine and Fleet Division of Ethyl Corp.'s Technical Service Department, described his experiences using chassis dynamometers and maintenance records to improve operating economy at this F & L Meeting. Based on a series of tests made in cooperation with the St. Louis Public Service Co., the report summarized the functions of the chassis dynamometer in a fleet operation:

1. As a general inspection tool after maintenance crews have completed their work;

2. As a spot check tool for checking the caliber of maintenance procedures;

3. As a means of determining proper adjustment standards of ignition timing, valve lash, spark plug gap settings, carburetor calibration, and so forth for use in the particular fleet;

4. For special problems and trouble shooting;

5. To find the effect of adjustment changes on fuel economy;

6. To determine if decreased engine road failures and driver complaints are obtained on a group of vehicles which are inspected and adjusted with the aid of the chassis dynamometer.

Gay's conclusion was that a chassis dynamometer can be used to improve fuel economy and maintenance practices and to reduce road failures. However, carburetor adjustments to improve fuel economy must be checked over a period of a year to eliminate the effect of seasonal mileage changes.

During discussion following his paper, Gay pointed out that one of the most important variables affecting vehicle octane requirements was the variation in ignition timing from cylinder to cylinder caused by wear and back lash in the gear train driving the distributor. He also emphasized that the type of dynamometer used in his investigations was a design specifically intended for maintenance purposes, incorporating two small rolls for absorbing the power of the rear wheels of the vehicle. Thus it is not suitable for prolonged periods of operation under high loads because of tire damage that will result. For research work, a single large roll about 6 ft in diameter is required. The necessity for special loading mechanism in the research dynamometer to simulate full throttle level road acceleration and hill climbing conditions makes the research type unit a very much more expensive installation than the maintenance type.

Supercharging Diesels Step In Engine Evolution

by J. H. MACPHERSON, Jr., Field Editor

NORTHERN CALIFORNIA Section, May 13 – R. Tom Sawyer, manager of American Locomotive Co.'s Research Department, was speaker at this diesel meeting. Sawyer was introduced by Technical Chairman Elton B. Fox, and spoke on "The Turbocharged Diesel Locomotive."

Tracing development of the turbocharged diesel locomotive over the past decade, Sawyer pointed out that the first engines were made without supercharging, but as requirements developed for more power in a limited space, supercharging became necessary. He showed performance curves for the latest Alco turbocharged diesel, which has remarkably low specific fuel consumption at its rated power. He stressed the fact that high specific power output and high bmep are possible because of the particular application of the engine – intermittent high load operation.

Unique Alco piston design, he said, makes use of a steel crown welded to the piston to provide an unusually rugged design. Diesel engines must be designed for the particular application in which they are to be used.

Sawyer illustrated Alco's various locomotives, and included a series of slides of locomotive construction from original framework to final construction of the cab. With his slides, he emphasized the many safety measures provided and the various devices designed to make operation as nearly automatic as possible.

Experience with diesel electric powerplants has shown, he said, that it is necessary to provide adequate forced draft cooling for the electric motors so that high speed operation under hot conditions, such as crossing the California desert, is possible without injury to the motor insulation.

Directs Attention To Character of Car Market

by W. F. SHERMAN, Field Editor

DETROIT Section, May 19 – The automobile industry can produce any kind of a car that is needed in any quantity and deliver it any place it is wanted at any designated time, but has never set out to see that everyone who could profitably use a car had one, Dr Franklin R. Cawl, a merchandising specialist, declared at this meeting of the Detroit Section.

Cawl, director of marketing and research for Kudner Agency, Inc., spoke on "Trends Influencing Automotive Design."

The industry has sold the public the second largest commodity in dollars that the average family is likely to buy in its lifetime, in greater numbers than they ever purchased that basic commodity – a home, he added.

However, there are basic changes taking place which will affect the kind of automobile that should be designed for future selling.

First, economic shifts are taking place that are changing our ideas of markets; income groups are changing; the farmer is becoming a processor as well as a grower.

Second, standards of living are changing, and there are some general readjustments in our economy.

Third, people are migrating, to the west and to the south; these changes may mean a demand for cheaper cars with greater utility value.

Fourth, money is becoming a questionable medium of exchange (it takes fewer bushels of wheat at today's prices to buy a car than it took in 1939).

Fifth, new materials will affect design.

Sixth, we are running short of other materials and will have to substitute.

Seventh, the laws we have always lived by are being made obsolete and

THOMAS

. . . . of Southern New England

Kenneth F. Thomas has a neat gift of producing a vital question for every speaker at every Section meeting that helps start discussions on the road to liveliness. Coupled with a general air of friendliness and confidence, this enthusiasm for SAE affairs has made 1946-1947 a good year for Southern New England Section.

Thomas got his BS in engineering at University of Pennsylvania, and his MA in business administration from Wharton School. He taught "Fundamentals of Machine Design" for a year, then became plant engineer and assistant superintendent for Perkasie Silk Mills. From 1935 until 1940, he was with SKF Industries, Inc., first as development sales engineer and then as district sales engineer in the Hartford territory. He had been manufacturer's representative for five engineering companies, and last year formed his own firm – the Kenneth F. Thomas Co. – handling bearings, gears, and a variety of allied products.

Kenneth F. Thomas

During the war he was coordinating chairman of the War Production and Engineering Council for Northern Connecticut. He belongs to the American Society of Tool Engineers, Hartford Engineers Club, and the Institute of Aeronautical Sciences. He has been a registered professional engineer in Connecticut since 1942.

But Section members know him best for his broad smile and warm handshake.

by A. M. Watson, Field Editor.

COCHRANE

. . . . of Southern California

R. W. Cochrane's "Cowboy" handle has something to do with a horse and a little more to do with an authentic yell to go with it. However acquired, it has stuck tight with the help of his many friends – not only in L. A., where he is White Motor Co.'s branch manager, but in the entire central section of the country that he covered when he was White's wholesale manager, headquartered in Denver.

Cochrane lives for his Saturday morning golf game. For one who plays only for fun, his scorecard looks pretty good.

He also has a penchant for unusual ties – "the louder, the better," he says. His family is quite used to canvassing every men's store in town to keep him adorned.

He loves entertaining, and is a perfect host. He has a neat facility for leading conversations around to accommodate one of his little stories, each of which he remembers forever.

R. W. Cochrane

Mrs. Cochrane, who is as Irish as her nickname "Mickey," has a sense of humor to equal her husband's. Together they have laughed their way through good times and lean times. Their three children – two boys and a girl, two of them married – have the same spark.

Mr. and Mrs. Cochrane are bound for Ireland, England, and France next month – primarily Ireland, although certainly neither of them needs to kiss the Blarney stone.

By R. W. Bixler, Field Editor.

DONNER

. . . . of Salt Lake City

Ernest R. Donner began his active career with "black" gangs on steam vessels on the high seas, working up from oiler and water tender. At the early age of twenty he got his third assistant engineer's license. Six years later he held a chief engineer's license for steam vessels of any tonnage or horsepower.

After traveling far and seeing most of the world's ports, Donner gave up the rough life of the seas in 1927, and joined Standard Oil Co. of Calif., as a lubrication engineer. Until 1941 he was located in Washington and Oregon doing varied fuel and lubrication work. Then he came to Salt Lake City as fuel and lubrication engineer for Standard Oil Co.

Besides being an expert on oils and greases for heavy-duty truck operations, Donner is an expert story teller. As for hobbies, he says he is kept quite busy helping Mrs. Donner make puppets. Whenever he finds the chance, though, you may find him playing penny ante poker or puttering in his yard at home.

Ernest R. Donner

—By Clyde Sissman, Field Editor.

This is the last set of biographies of 1946-1947 Section chairmen. Three chairmen-elect will be featured in the September issue, beginning a new series of articles about 1947-1948 chairmen.

the effects of new ones are becoming apparent, and

Eighth, new devices like the automobile telephone will affect the design of vehicles.

The public would like to use its automobiles even more than it does, so there will be growing need for parking facilities, plus changes in the vehicles themselves. Annoyances to which the public objects include:

1. Too much vibration.
2. Too many drafts.
3. Lack of outside rear vision.
4. Improper sun visors (after all these years).
5. Too many squeaks due to improper use of rivets or lockwashers.
6. Lack of new signaling devices in plain sight on the dashboard to tell the condition of more parts of the car than we have a check on today. (The public knows that cars are complex and can get out of order. They want some indicators as to where the trouble is or a warning to check certain parts before there is any real trouble.)
7. Need of better safety glass.
8. Lack of rear window wipers.
9. Noisy car interiors.

The public is conscious of safety devices, as is evidenced by demands for:

1. All doors to be hinged in front.
2. Lifeguard inner tube.
3. Backup lights.
4. Top-speed governors.
5. Better brakes.
6. Stronger bodies.
7. Better visibility.

Other items Cawl said the driving public is asking for are:

1. Real defrosting equipment which is so necessary in bad winter weather to keep a car on the road.
2. Lights that move with the steering wheel so that greater use may be made of cars at night. Many people find night-driving much more difficult than day-driving and want every help they can possibly get to make it easier.
3. Fog lights or some method of dispelling fog. (Perhaps some form of radar could be employed here.)
4. Built-in jacks. (We are not always where help can be obtained quickly nor are we always in a position to get a jack under the car. Any help in this direction will certainly be appreciated.)
5. Tire chains that are easier to put on and take off.

Zeder Also a Featured Speaker

All of the personal problems of attaining success in the engineering world are vulnerable to trained attack, according to James C. Zeder, chairman, Engineering Board, Chrysler Corp., who was also a featured speaker at this session. He declared that personal development of engineers is important because, if neglected, it applies brakes to personal progress.

"More often than not," Zeder asserted, "our real progress depends on how well we tackle the non-technical obstacles that frequently get in our way."

He outlined in bold terms some of the typical complaints of engineers:

1. "It is almost impossible to secure recognition or greater income."
2. "The company is not progressive."
3. "Progress in my company can be gained only by the 'high pressure boys.'"
4. "There's no future because there are too many older men ahead of me."
5. "There's no credit for routine work, and I never get the spectacular jobs."
6. "The management completely disregards the true importance of the field of engineering I'm in, so that little attention is paid to my work."
7. "There's no real money in engineering."
8. "Engineering doesn't have enough voice in management decisions affecting engineering."
9. "Engineering does the work, but someone else gets the credit."
10. "Engineers spend most of their time correcting other people's mistakes."

Precision Suffers Outside Field

"Unfortunately, when we encounter obstacles outside our own backyard of engineering, we tend to throw away the precision tools of reasoning; instead we start hacking away with the erratic implements of emotion. We lose all sense of proportion because, instead of using a steel rule, we try to size up the situation with an elastic tape measure. And the more disturbed we get, the more we stretch the tape," Zeder said.

Solution of the engineer's problem demands more than mere technical proficiency. Zeder cited the finding of specialists in human behavior . . . that above everything else the most widespread and useful characteristic of success is the ability to get along with people. The second characteristic of successful people is their habit of looking beyond their own department or their own activity to find ways in which they can make their own efforts contribute more to the rest of the organization. This is not altruism, Zeder said, but they have discovered that their own market value goes up whenever they extend their services.

These, and the other bits of philosophy about success, were boiled down by Zeder into this:

"Each one of us can make more progress in Engineering if we are willing to carry on a serious program of self-development and self-adjustment. By so doing, we will gain the stature and maintain the attitude that will give us capacity for progress beyond whatever problems we meet."

President Frudden Addresses Section

President Frudden made his first appearance before the Detroit Section as coffee speaker. Much too briefly he discussed the engineering opportunities that exist in the agricultural equipment industry. He revealed some of the ingenuity of design of tractors, tires, plows and implements, citing the fact that harvesting equipment now is versatile and ingenious and efficient

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beyond the point even indicated in handbooks, textbooks and catalogs written just a short time ago.

Farm productivity is on the way up, he declared, and he urged that engineers go ahead with their efforts so it will be possible to produce more at much less cost.

Williamsport Holds First Ladies' Night

by ROBERT B. INGRAM, Field Editor

WILLIAMSPORT Group, June 15 – Williamsport Group's first ladies night, and one of its biggest meetings of the year, began with an afternoon inspection trip of the Piper plant in Lock Haven, dinner at the country club, and ended with a talk by Dexter Rosen, staff engineer of Bell Aircraft Co.

Speaking on "The Future of Jet Propulsion and Helicopters," Rosen predicted a bright future for both jets and helicopters. But, he believes, they will not be used in large quantities for five or ten years.

Discussion Nontechnical

Rosen supplemented his talk with some interesting films in honor of ladies night, and did not go deeply into technical details. "Engines are fundamentally of the airstream or non-airstream type," he said. "Airstream simply means that the engine depends basically on atmospheric air for its power source, and the conventional piston-type engine is the most familiar of this type. The rocket is the only present non-airstream engine.

Jets, he said, are also airstream-type engines, and can be divided into three large groups – turbo, pulse, and ram jets. He illustrated the various types with sketches, and outlined principal operating differences.

A summary of the main differences between the various types of non-airstream and airstream engines was shown by this table:

Type Engine	Airspeed Range mph	Specific Fuel Consumption in lb fuel per lb thrust per hr
Piston	0-400	0.50
Turbojet	400-600	1.0 -1.2
Ramjet	300 up	4.0 -8.0
Pulsejet	400-600	2.0 -3.0
Rocket	400- ?	18.0

Turning to helicopters, Rosen first showed that their chief value at present is for utility, not public use, because of high initial cost and upkeep.

General public use is out of the question now, he said. Taking into consideration such figures as $5000 per year depreciation cost, Rosen figures that it would cost about $27.80 for each hour of operating time. This was based on 700 hr of operating time per year.

General Use Remote

The speaker mentioned the various types of helicopter in use besides the Bell, and pointed out their main characteristics. Looking to the future, he predicted that helicopters will be widely used in specialized fields by 1950 or 1952. However, there is plenty of development work in order before they can be widely used by the public.

New Members Qualified

These applicants who have qualified for admission to the Society have been welcomed into membership between June 10, 1947, and July 10, 1947.

The various grades of membership are indicated by: (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate Member; (SM) Service Member; (FM) Foreign Member.

Baltimore Section: Arnett J. Franchi (A), Robert V. Rosenwald (J).

British Columbia Section: Guy Barclay (M), John Frederick De Wolfe (A), Thomas Williams (A).

Buffalo Section: Robert R. Bridgman (M), David Roy Shoults (M).

Canadian Section: Austin John Berry (A), M. Grant Coates (A), Joseph Wilson Dyer (M), Eric Lionel Houston (J), Harold C. Thomas (A), Edgar Joseph Wadham (J).

Chicago Section: Harry W. Angus (A), James E. Ashton (A), Fred Frank DeMuth (J), Howard T. Eaton, Jr. (A), Ralph D. Feick (M), Frederick Thomas Finnigan (J), Fred J. Gerling (M), Audley E. Harnsberger (M), Frank Hlavek (A), Marshall Dean Klinger (J), Ronald Walter McIntyre (J), Bertel S. Nelson (M), Walter G. Newnan (M), Stephen L. Shira (A), LeRoy Francis Slivinski (J).

Cleveland Section: George A. Butz, Jr. (J), Harold H. Christensen (J), Richard H. Gale (A), Lawrence L. Gilbert (J), Daniel Wm. Harmon (J), William B. Hargadon (M), E. J. Hrdlicka, Jr. (M), Wesley E. Messing (J), Walter M. Shaffer (M), William B. Wier (M), Fred A. Wilcox (J).

Dayton Section: D. Franklin Boyd (J), Glenn E. Douglass (A), Adolph E. Rahm (A), Thomas L. Sherman (M), Edwin M. Wright (M).

Detroit Section: William R. Benk, Jr. (J), Calvin James Bressler (J), Malcolm C. Campbell (A), George T. Christopher (M), Hubert M. Clark (M), Boyde Clemons Cormany (A), George R. Coss (M), Philip A. Essi (M), Irving F. Gillespie (J), William K. Ginman (A), Lee Hall (J), Paul B. Hartman (M), John P. Henson (J), A. E. Hess (A), Edgar Livingston Hollifield (J), Arthur E. Huffman (M), Hans C. Johnson (M), A. Elliott Kimberly (M), Robert Roy

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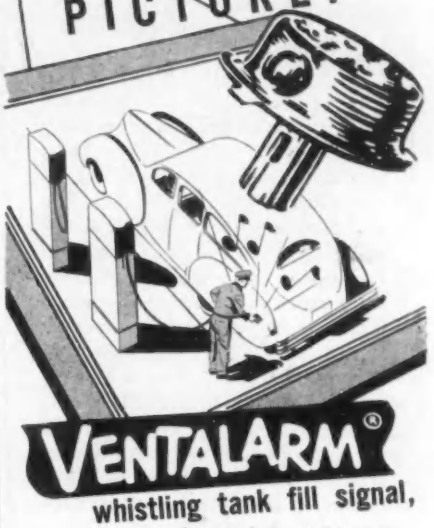

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Kansas City Section: John E. Cox (A), Dallas Vincent Walker (M).

Metropolitan Section: Ion Jacques Bochory (A), Bernard M. Brod (J), Martin F. Christensen (M), Alton B. Crampton (M), Keith N. Crowell (J), Sidney Faden (A), R. M. Franey (M), Sam Louis Glasberg (A), George O. Hiers (M), Samuel Paul Johnston (M), Rolland R. King (A), Hugh Wallace MacDonald (M), Albert J. Magee (J), William Barrett Mark (J), J. O. McLean (A), Natwar Mulchand Parekh (J), Ernest Francis Pollard (A), Robert Schechter (J), Victor Warshaw (J), Yet Lin Yee (J).

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Milwaukee Section: W. J. Adams, Jr. (M), Walter J. Beyer (M), Charles W. Decker (J), T. Russell Moyle (M), R. P. O'Connell (A).

Mohawk-Hudson Group: William Frost Moore (J), Gilbert S. Sullivan (A).

New England Section: Charles Henry Huck (A), John B. Perkins (A), George F. Young (A).

Northern California Section: F. Hal Higgins (A), Horton A. McKim (M), Joseph DeWitt Sanderson (J), Eugene A. Winslow (A).

Northwest Section: Oliver Paul Cromwell (A), Kenneth Dean Endelman (A), E. A. Heckendorf (A), Earl B. Maxwell (A), Earl Eugene Phillips (M).

Oregon Section: Leonard A. Cox (A) Charles W. Simonsen (A).

Peoria Section: Harold W. Jeter (M), Karl J. Mogk (M).

Philadelphia Section: Arnold Andrew Dach (J), William J. Fitzsimmons (M), Charles A. Knapp (J), John F. Male (J), Robert Anthony Moore (J), Walter L. Newsom (A), Charles P. Orr (A), Paul H. H. Snyder (J), Bernard Miller Sturgis (M), Alfred E. Townsend (J), James C. Wise (J).

Pittsburgh Section: Robert Ralston Chrisman (A), Floyd F. Curtin (A), Thomas M. McBroom (A).

St. Louis Section: Niels C. Beck (M), Charles William Brown (A), Hubert C. Moog (A), Robert Gerry Tuell (J).

San Diego Section: Robert Millard Barr (J), Albert E. Heflin (A), Lynn Stroud (M).

Southern California Section: Alden E. Acker (M), George K. Anderson, Jr. (A), Roy F. Armstrong (A), C. R. Copeland (A), Everett M. Gray (A), James E. Howry (A), Cedric Leinbach (A), Pichel Wilson Pichel (J), Ovila A. Richer (A), Eric Swarthe (M), David Edwin Weber (A), George Thomas Wilson (J).

Southern New England Section: Robert L. Ballard (J), Roland Kenneth Blakeslee (M), George S. Budney (J), Henry J. Dzielenski (J), S. Herbert Hilleboe, Jr. (J), Norman B. Newton (J), Joseph Thomas Osterman (J), Byron T. Virtue (M).

Spokane Intermountain Section: Stanley Power (A).

Syracuse Section: David Templar Doman (J).

Texas Section: Walter A. Hoot (A).

Twin City Section: G. E. Buske (M), Edward B. Nechville (J).

Virginia Group: Charles Wyndham Galloway (M).

Washington Section: Myles W. English (A), Lyman Carlyle Fisher (SM), Lt. Comdr.* James L. Ingoldsby (SM), J. Lawrence Wilkins (A).

Western Michigan Section: Edward G. Carlson (J).

Wichita Section: Harold W. Zipp (M).

Outside of Section Territory: Mando S. Ariens (M), Commercial Solvents Corp. (Aff.) Rep: Wilbur L. Kelo, Russell George Hurschman (A), Clarence T. Soenke (A), Harry B. Thompson, Jr. (J).

Foreign: Edward Roland Dawtrey (FM), England; Ralph Eckstein (A), British West Indies; Michael Ward Kendall (FM), England; Umberto Remigio Mazzarol (A), South Australia.

Applications Received

The applications for membership received between June 10, 1947, and July 10, 1947, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

Baltimore Section: Arthur N. Curl, Yao-Hsi Keng, William M. Meyer III, Joseph Trepanowsky.

British Columbia Group: George Wesley Atchison, William Frank Rogers.

Canadian Section: John Devlin, Lewis William Parmenter, Paul M. S. Stafford.

Chicago Section: Ivan G. Anderson, Joseph Pountifex Chamberlain, Ching Fu Chen, Ralph Gerald Harmon, Lloyd B. Little, James Norton Low, William Gifford Myers, Thaddeus P. Perry, Steven F. Rams, Donald P. Ryder, William M. Whitson, Jr.

Cincinnati Section: Clarence D. Johnson.

Cleveland Section: Vaughn Y. Bell, Kenneth A. Brown, Larry H. Kline, Nathan H. Biddle, Anthony D. Ziherl.

Dayton Section: Major Langdon F. Ayres, Arthur K. Dondlinger, Lloyd Duane Yates.

Detroit Section: John William Asselstine, George W. Bleckner, Benjamin F. Brender, Edward George Chapaitis, William A. Clark, J. Verne Coontz, Ng. Paul Hing, David R. Hubbs, Eric William August Lange, John H. Lundy, Charles H. Morris, Edward F. Piotrowski, Charles R. Shanks, Reed Morgan Syler, Talaat E. A. Youssef.

Indiana Section: Robert F. Bostock, W. S. Broffitt, Edward M. Diss, C. H. Eberhard.

Metropolitan Section: Orlo Jay Blomquist, George J. Dashefsky, Sidney Davidson, Kenneth E. Forster, Robert Les Francis, Harland Alexander Gray, Jr., Milton Menkus, Gerard A. Paquin, Lloyd B. Poole, Gilbert Roth, William Sternlicht, Spencer Allen Tucker, H. Stuart Wood.

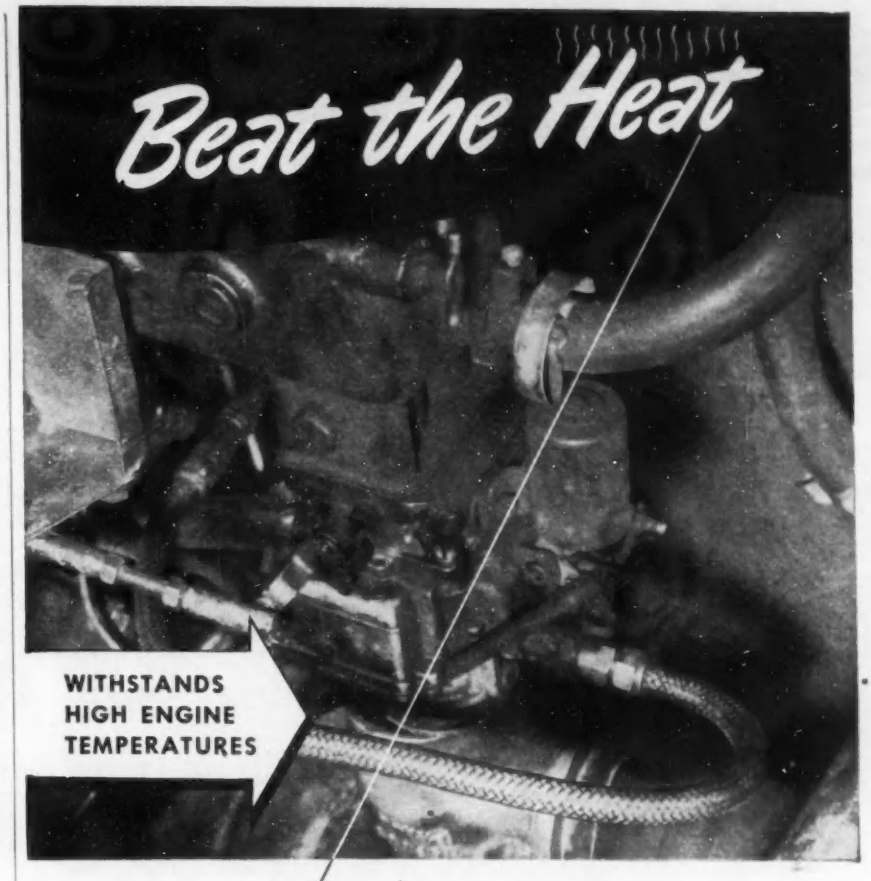
Mid-Continent Section: Roy M. Franks, Jr., Jack Harold Laubach, G. N. Thresher.

Milwaukee Section: Coy N. Chandler, Rene Joseph Gehl, Winston H. McPhail, Kay Ichi Nakagiri.

New England Section: William B. Jackson, Wellington G. Rodgers, Thaxter A. Williams.

Northwest Section: Elmer L. Alverts.

Oregon Section: William James Skinner.



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Pittsburgh Section: William V. Spurlin, Leslie Arthur Toon.

St. Louis Section: Raymond K. Bucher, Thomas R. Magowan.

San Diego Section: Hamilton Laurie Stone.

Southern California Section: F. Besancon, Wetmore Hodges, Jr., Thomas P. Jackson, William Joseph Leas, Jr., Herbert T. Lund, Cleve O'Neil, Maurice Nelles, James Harold Seay, F. R. Wineland.

Southern New England Section: Edward Max Bach, George F. Hausmann, Richard C. Hurd, Howell W. Miller.

Twin City Section: Robert G. Hoch, Virgil Howard Johnson, Carroll M. Martenson, James Frederick Sullivan, Jr.

Virginia Group: John L. Frank, Jr., Hunter W. Spencer.

Washington Section: Fred H. Esch, Green Rayner Gaillard, Bernard Goldberg, Francis J. Reilly, Com. Norval R. Richardson, Carl C. Saal.

Wichita Section: John B. Hardee, John M. Maloney, W. L. Pursell.

Outside of Section Territory: Frank T. Carroll, Jr., Eugene Howard Case, David Wallace Dinsmore, Louis E. Endsley, Jr., R. L. Jones, Robert W. Stieg, William F. White.

Foreign: Hilton Harold Batt, Australia; Walter James Belgrove, England; Stanley John Breeze, England; Dante Giacosa, Italy; Eric Granville Vivian Gill, England; N. K. Gopalan, England; Don Hunter, Australia; John Nicholson McHattie, England; Salahattin Pasiner, Turkey; Theodor Paul Wirz, Mexico.

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Brake Design and Testing

cont. from p. 77

neither of these methods is considered simple enough for ordinary police work and, in most cases, would be too costly.

The subcommittee hopes to see the development of a simple mechanical instrument for measuring stopping distances of any vehicle—regardless of size, weight, speed, or mechanical condition—with accuracy suitable for enforcement work.

Considerable road testing of brakes is going on continually, as is dynamometer testing. At least four large companies are running road tests over the same course on a main U. S. highway, using the same test procedure. A number of manufacturers are carrying on dynamometer test work in their own plants. An attempt will be made to correlate these two classes of brake testing.

In connection with dynamometer testing, a subcommittee headed by R. K. Super, Timken-Detroit Axle Co., is endeavoring to determine those factors of a brake system which indicate brake performance, a uniform test procedure and methods of measurement, and the required instrumentation and types of machine for dynamometer testing.

A tentative recommendation has been worked out covering the test conditions for measuring stopping distances. The recommendation will cover such factors as the test road surface, which should be dry, hard, smooth, and level; conditions such as wind under which tests should be run in both directions and averaged; and the types of instrument required.

An important phase of the overall Brake Committee project is the preparation of a uniform nomenclature so that everyone concerned with the design, maintenance, and testing of brake systems will talk the same technical language and use the same terms. This

subcommittee, headed by Burns Dick, of Wagner Electric Corp., proposes to establish fundamental definitions under the various brake systems, such as hydraulic, air, vacuum, mechanical and parking, electrical, and other absorption devices.

Hunt Device to Measure Vehicle Exhaust Smoke

DEVELOPMENT of instrumentation for measurement of vehicle exhaust smoke density by enforcement officials has been undertaken by a newly-created subcommittee of the SAE Motorcoach and Motor Truck Committee. Current activities in California to control the amount of engine exhaust smoke emitted, particularly by diesels, spurred initiation of the SAE project.

Concern of the SAE Subcommittee on Measurement of Automotive Smoke is with the means of measuring smoke densities and establishment of tolerable limits on smoke densities, rather than with ways and means of reducing smoke.

According to Chairman H. L. Knudsen, Cummins Engine Co., the scope of his group is as follows:

1. To find a satisfactory means of instantaneously measuring and recording smoke densities, if possible;

2. To determine if smoke can be measured by enforcement authorities in the field and, if so, with what degree of accuracy and usefulness in prosecuting offenders;

3. To establish ground rules for measuring smoke and to gather statistical data on smoke emitted from vehicles.

A. J. Blackwood, Esso Laboratories, noted that CRC developed a smoke meter for research purposes only. He will investigate the possibilities of adapting it to enforcement use. Possibilities of using an optical device for smoke measuring also are being looked into.

The innumerable variables contributing to smoke density obviate the need for accurate instrumentation, advised H. C. Dickinson, National Bureau of Standards.

In addition to Blackwood and Dickinson, Chairman Knudsen's group consists of A. S. Leonard, Cummins Engine Co.; L. A. Blanc, Caterpillar Tractor Co.; O. D. Treiber, Hercules Motors Corp.; E. N. Hatch, New York City Transit System; G. W. Johnson, Bowman Dairy Co.; G. F. Roddewig, GMC Truck & Coach Division; F. G. Shoemaker, GMC Detroit Diesel Engine Division; H. G. Smith, Buda Co.; J. L. S. Snead, Jr., Consolidated Freightways, Inc.; and H. R. Porter, Standard Oil Co. of Calif.

Probe Tractor Ignition For Small Aero Engine

ADAPTATION of automotive-type ignition components to personal plane powerplants represents one phase of the SAE Low-Horsepower Engine Committee's program to reduce cost of light plane engines by developing adequate standards.

Proposals are now under consideration to standardize on drives for combination ignition units based on SAE tractor magneto standards. Included are a dual distributor, dual magneto, and a combination distributor and magneto.

There are at present no standards of this type for small planes. These proposals will be sent to ignition system manufacturers for comments.

Lack of standardization of generators and starters is another headache for the personal plane industry which the Committee hopes to remedy. There are currently almost a score of starter and generator mounts used by low-horsepower engine manufacturers. They run the gamut of 2-hole, 3-hole,

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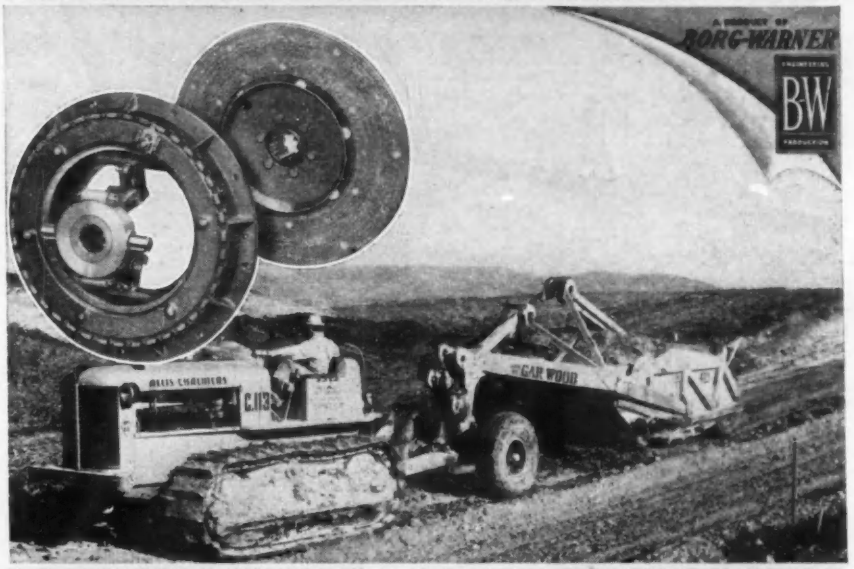

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and 4-hole mountings and some use platform mountings.

J. B. Hiday, of Delco Remy Division, GMC, who has prepared tentative performance specifications for these units for the SAE Aircraft Electrical Equipment Committee, noted that it probably will be easier to standardize generators than starters since a greater variety of starters exists.

Chairman L. A. Majneri, Warner Aircraft Corp., assigned P. B. Martin, Lycoming Division, Aviation Corp., to head a subcommittee that will prepare proposed standards for generator mountings. These standards will specify mounting dimensions, arrangements and, if possible, envelope dimensions. Any standards developed will apply to new designs only.

To keep the number of standards used on small engines to a minimum, Chairman Majneri will work up a proposal using the small fuel injector flange standard as the basis for a hydraulic gear-pump flange standard.

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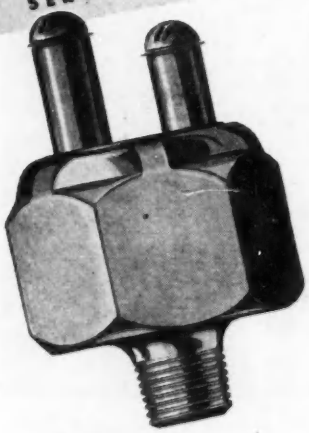

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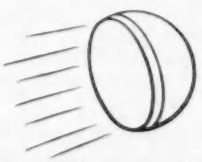

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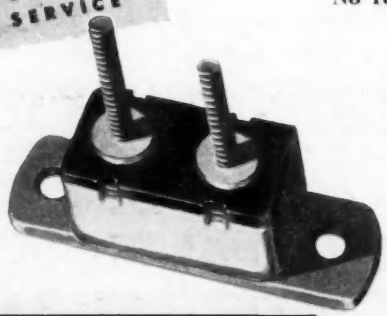

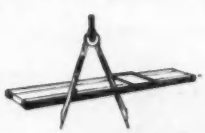

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Feelevator

cont. from p. 72

tab sets up aerodynamic forces which help the pilot move the elevator.

The feelevators also are connected directly to the pilot's control column. The force needed to move the feelevator adds to the force needed to deflect the tab spring. Fig. 3 is a diagram of the connections.

This arrangement of feelevators plus spring tabs appears to be free of the disadvantages of some of the other solutions of the problem of providing controls which can be handled satisfactorily by the pilot. For example, the power-boost system requires a lot of maintenance because it is susceptible to a host of mechanical and hydraulic failures – failures which do not plague feelevators. (Paper "A Longitudinal Control System for High Speed Aircraft," presented at SAE National Aeronautic Meeting, on April 10, 1947.)

Tire Synthetics Span Century of Research

Digest of paper

By J. A. BRITTON, JR.

Stanco Distributors, Inc.

OVER 100 years ago chemists started tinkering with test tubes to duplicate in the laboratory what Nature provides in the rubber tree. The know-how of today's synthetic rubber making grew by accretions . . . pyramiding discovery on discovery.

As early as 1826 Faraday demonstrated that rubber was a hydrocarbon. Next important contribution was made in 1860 by an Englishman, Williams, who isolated a water-white low-boiling liquid – which he called isoprene – from a destructive distillation of rubber.

In 1875 Bouchardat converted isoprene into an elastic mass, similar in all respects to rubber, but not nearly as good. He was really going at it backwards, getting his raw material from rubber and then turning it back into an inferior rubber.

History tells us that the switch from analysis to synthesis of rubber was sparked by Tilden, an English chemist. In 1882 he produced isoprene from turpentine. Until 1910 little, if any, progress was made. Then another Englishman, Mathews, found that metallic sodium greatly increased the rate of polymerization reaction. About the same time, a Russian, Kondakov, departed from the practice of using isoprene as a starting point and turned to butadiene, which today represents about 75% of the raw materials in the

Government's synthetic rubber program.

Coincident with Konkakov's work, Hoffman in Germany experimented with methyl butadiene and metallic sodium with which he produced Buna rubber.

But it wasn't until the 1920's that the first commercially-produced synthetic rubber hit the market. While coping with an antifreeze problem, Dr. Patrick, in Kansas City, accidently discovered that he had developed an elastomer which eventually sold under the trade name of Thickol. And in the late 1920's, Niewland and Carruthers' working independently, developed what became widely known as neoprene.

These two products were introduced for their one outstanding quality – oil resistance. In the next 10 years most gasoline and fuel oil hose was made from one or the other.

Time-Saving Catalyst

Rubber synthesis got its big spurt when a catalyst was found that reduced polymerization (linking together atoms in a group) from a two to six months process to one completed in several hours. The product of this discovery – a two component polymer of 75% butadiene and 25% styrene – was Buna S.

Since Buna S cost so much more than natural rubber and had no apparent advantages, it took a wartime rubber shortage to spur development of a synthetic rubber industry in this country. (Paper "Synthetic Rubber," was presented at SAE Mid-Continent Section, Norman, Okla., Oct. 11, 1946.)

Welder Owes Success To Recent Advances

Digest of paper

By C. ARTHUR LIND

Scott Foster & Co., Ltd.

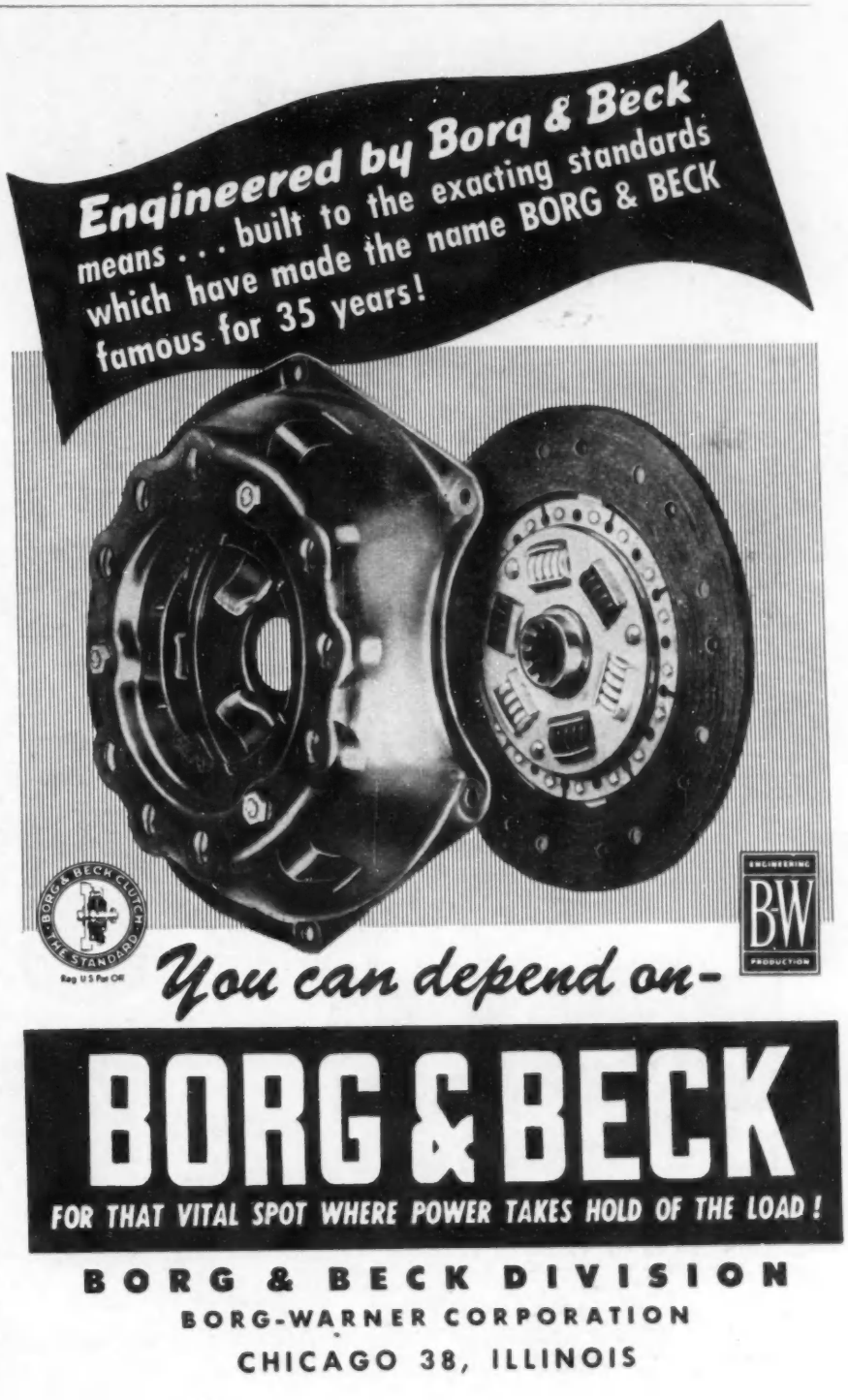
RELIABILITY of modern AC transformer-type arc welders stems from the innovation of arc-boosters and improved current control, Lind declares. He shows how the cure for two main ills remedied other troubles as well.

Poor arc-striking characteristics were common with AC welders until the arc-booster came along. This unit allows all or part of the full transformer output to flow through the arc for a short time after striking. It also gives control over penetration at the start of each bead so that welds are obtained equal in quality to those with DC equipment.

Because of poor arc-striking properties and instability, early AC welders used OC (open circuit) voltage high enough to be dangerous to the operator. High OC voltage produced a low power factor and condensers were added to pull it up.

Since the arc-booster licked the arc-striking problem, modern welders use much lower and safe OC voltage – between 55 and 60v. Such low OC voltage yields a high power factor, eliminating the need for condensers. Condensers add to the machine's cost; they also induce high transient voltages in other transformer welders on the same line because of the steep wave front of current that flows each time a welder is switched on the circuit.

The second welder modification was the change in current control from troublesome electric taps to mechanical movement of one coil in relation to another. A movable iron core varies the reluctance of the magnetic flux circuit. This gives a continuous current variation rather than a limited number of "heats" – as a welder would call it. (Paper "Some Recent Developments in Arc Welding Equipment," was presented at SAE British Columbia Group, Vancouver, Feb. 12, 1947.)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Finds Metal Cheaper Than Fabric In Manufacturing Personal Plane

Based on a paper

By WALTER C. JAMOUNEAU

Piper Aircraft Corp.

MANUFACTURING economics favors metal construction to fabric covering for light airplanes.

Painting operations for composite construction demand more exacting plant requirements. Air contaminated by paint and dope for spraying fabrics must be either cleaned or expelled from the room. This means large heat losses and power requirements for discharge fans or an elaborate air washing process. And these highly flammable covering materials boost insurance rates.

On the other hand, basic machine tools for producing sheet metal airplanes require greater dimensional capacity and more capital outlay per machine. In hand tools, the rivet gun replaces the welding torch—the basic joining tool for composite construction; but an assembly like a fuselage will require an equal number of rivet guns and welding torches.

Design and construction of a sheet metal assembly jig is less expensive than that of a welding jig since no thermal moments and stresses need be accounted for. But tooling for sheet metal assembly must be built to hold close tolerances to prevent unacceptable skin wrinkles. With the composite assembly it is possible to work to greater tolerances, except for matching fittings. The fabric contours itself over the entire frame.

The tubular steel fuselage poses a real inventory problem. A sizable range of tube sizes as well as welding and brazing rods is used. And the fact that 40 gal of dope and thinner are required to finish a typical light airplane points up the magnitude of the problem. A production rate of 200 airplanes per week involves the handling of 160 drums.

Accurate analysis of the material cost of each form of construction is handicapped by design differences. But for a fuselage structural shell, the cost list in Table 1 gives a general relationship based on current market prices. It can be seen that sheet metal holds a marked advantage in material cost and involves a much smaller investment in raw materials inventory.

Table 1—Comparison of Fuselage Structure Material Costs

Composite Type		Sheet Metal Type	
Steel Tubing	$54.04	Aluminum Sheet	$30.37
Steel Sheet-Strip	3.15	Aluminum Extrusions	10.28
Welding Rod	.35	Aluminum Castings	12.18
Wood Fairing Strips	1.79	Rivets	.54
Cotton Fabric and Tape	20.74		
Nitrate Dope	8.00		
Primer Paint	2.67		
Total	$90.74		$53.26

Table 2—Comparison of Fuselage Structure Labor Requirements

Composite Type	Time in Man-Hours	Sheet Metal Type	Time in Man-Hours
Cut-off-Shape Tube Ends	2.56	Cut-out-Form Bulkheads	.30
Tack Weld Tube Assembly	1.73	Shear Skin Sheets	.20
Weld Tubing Clusters	6.24	Flange-Form Skin Sheets	.15
Attach Fairing Struc.	1.00	Cut-off Stringers	.05
Prime Paint Frame	.28	Assemble and Rivet	10.20
Cover with Fabric	6.00	Misc. Machining	.30
Apply Dope Coats	2.70		
Total Man-Hours	20.51		11.20

The manufacturing time required to assemble this same fuselage is shown in Table 2 for both constructions. Ap-

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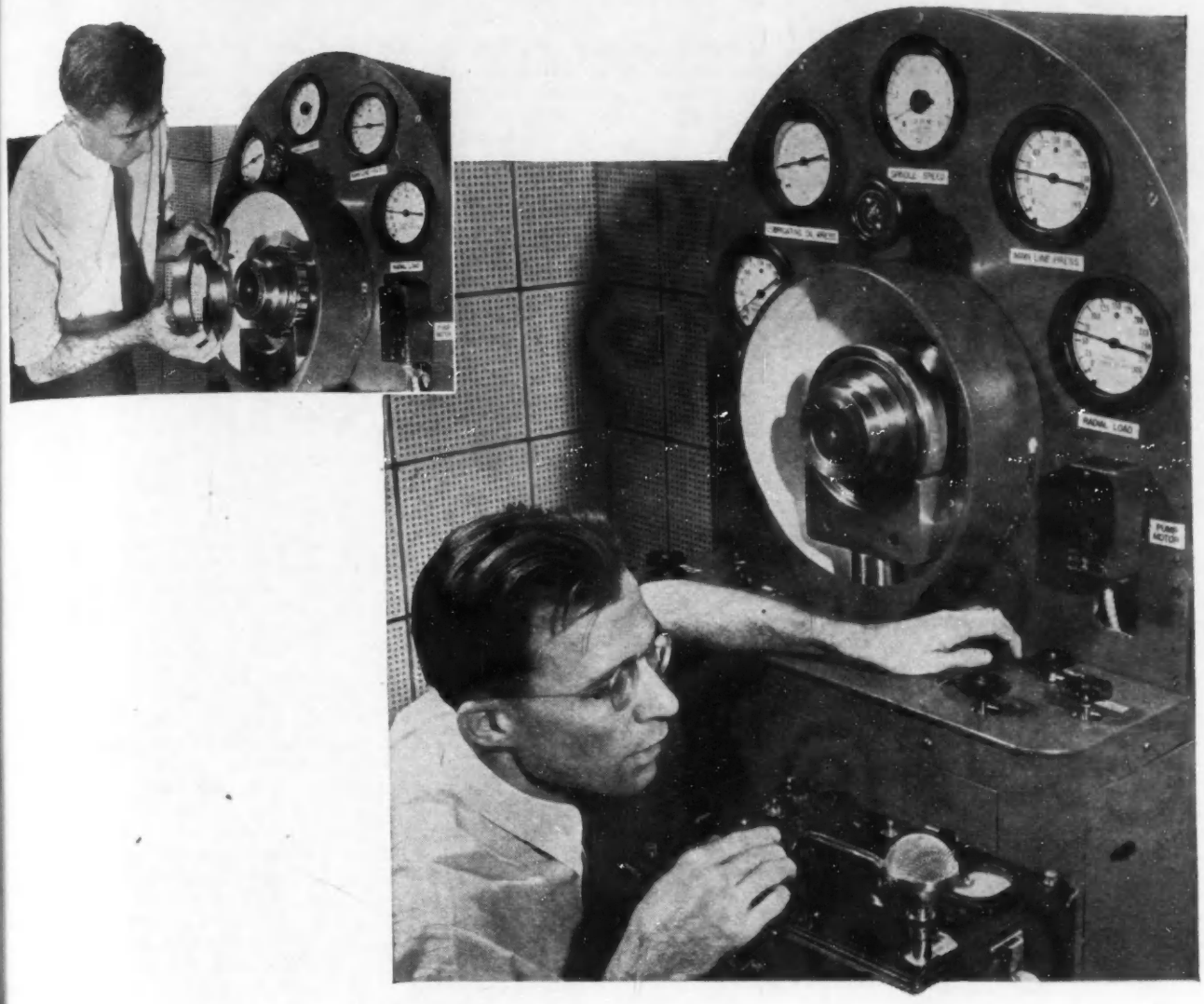


He Listens in Silence... to Silence

The noise that a roller bearing *doesn't* make speaks volumes for its quality. And Quiet is another word for Hyatt.

Since automobiles first lost their "roar" and began to acquire front parlor manners, Hyatt Quiet has been a byword in the industry. Through successive years—as speeds have become higher, loads heavier, service conditions more rugged—Hyatt has continued to meet specifications . . . with consistently finer roller bearings: dependable bearings that will *do* the job they are designed to do. Engineers and designers have come to expect this of us.

That is why we have more than 2 million dollars worth of equipment solely for inspecting each bearing in process of manufacture. And why we have, in addition, such elaborate special equipment as the sound test pictured here, for further verifying the uniformity and quality of each production unit . . . for continuing research, to make Hyatt Quiet *quieter*.

The great performance of millions of Hyatt Quiet Roller Bearings in cars, trucks and buses is the final "test" which proves their quality. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

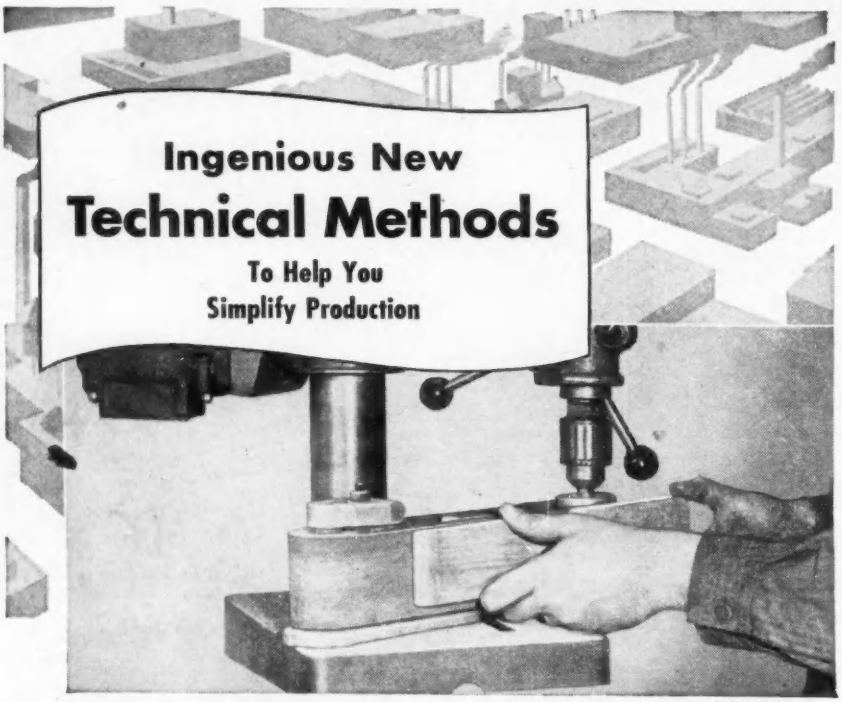
HYATT ROLLER BEARINGS

parently actual manufacturing time is much less for the sheet metal structure. Added to this saving is the decreased handling time resulting from fewer operations.

Significant differences exist in the inspection requirements for each form of construction. Torch welding is somewhat of an art; the inspector must keep close vigil over the work of each man to guard against reduction in quality. Inspection of riveted assemblies requires that each rivet be checked for quality. Unsatisfactory rivets or damaged skin may call for replacement of an entire skin panel.

The inspector of fabric-covered structures must also carefully check the initial tautness in fabric application. When applied too taut, drawing action of the dope will distort and buckle wing trailing edges, fuselage fairing, and longerons. Such defects may require recovering of the part.

Although the evidence gives the verdict to sheet metal structures, it must be remembered that this comparison deals solely with the manufacturing problem. A complete evaluation including maintenance would bring out many points in favor of the fabric-covered plane. (Paper "Comparison of Use of Mixed Structural Materials and Fabric Covering to All-Metal Construction for Personal Aircraft from a Manufacturing Viewpoint," was presented at SAE National Personal Aircraft Meeting, Wichita, May 1, 1947.)



NEW BELT SANDER FOR DRILL PRESS
Does Finishing Jobs Faster, Better

A new, simple, faster method for many surface finishing jobs on wood, metal, plastic and other materials has been announced by the OK Specialty Company of Chicago. The new finishing method takes the form of the OK Belt Sander, a drill press attachment.

The new sanding device weighs less than 5 pounds. It is made up of an aluminum base with backing plate or platen, a driven pulley mounted on ground steel shaft and running on precision ground ball bearings, and cast aluminum driver pulley mounted on ½" ground steel shaft to fit into the drill press chuck.

The base of the sander is bolted to a drill press table. Merely by moving the drill press table, the attachment can be adjusted to handle sanding belts from 26" to 36" in length.

The sander takes belts from ½" to 3" in width. Two sanding belts, one coarse grit and one fine grit, are furnished with each attachment. The device comes assembled ready for use with any drill press. Most efficient performance is achieved at 3500 to 5000 RPM. The sander stands 5" high, and the base measures 10½" long by 3¼" wide.

Another time-saver on the job is chewing gum. Chewing gum may be used even when hands are busy; and under dust conditions helps to keep the throat moist—prevents "false thirst." For these reasons many plant owners make Wrigley's Spearmint Gum available to everyone.

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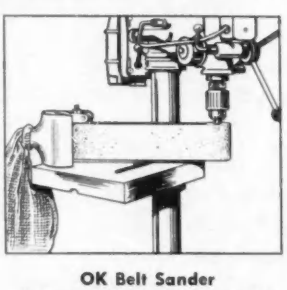

OK Belt Sander Assembled, Ready for Action

AB-69

Diesel Disorders Cease With Modified Design

Digest of paper

By L. R. MILLER

Inland Motor Freight

A LITTLE engineering ingenuity applied in the right places has worked many of the bugs out of diesel engines for the fleet operator. Design refinement at the trouble source halted failure of fuel pump governors, excessive part wear, loss of lubricating oil, and frequent overhauls.

Several years ago, Inland encountered fuel pump trouble due to burned-out governors. It was caused by clogging of oil passages by the dirty engine oil used to lubricate the governor. The remedy was to block off the engine oil from the fuel pump and to use the fuel itself to lubricate the governor.

This practice stopped governor failure due to faulty lubrication and saved operators many thousands of dollars.

Wear is the greatest factor to contend with in aiming for prolonged fuel pump life. Erratic performance such as loss of power, faulty acceleration and deceleration, and hard starting follow wear.

Wearing parts were first chrome plated; but results were disappointing. When a plated cam rotating at 1800 to 2000 rpm contacted a plated roller, the plating left one of them in the form of minute hard-chrome particles—fine enough to pass through two 100-mesh screens. The particles lodged in small pump needle bearings, passed into the injectors, and finally plugged the injector-tip orifices so completely that it was impossible to clear them. This resulted in the loss of a considerable number of units.

By plating only one part of the contacting surfaces, good results were achieved. Life of these parts was extended an average of 75%. It also was found practical to bring worn parts back to standard by hard-chrome plating; this makes a better part than a newly unplated one. One batch of such parts, plated at a cost of $75.00, produced what would have cost $525 new.

Another modification of the injector boosted performance and economy. Radical differences in oil consumption were noted after some engine tune-ups

or injector changes. Cooperation between the manufacturer and field men evolved a simple but effective cure.

It consisted of drilling through the injector fuel-return hole into the injector barrel and machining a groove in the barrel. This prevented lubricating oil from entering the injector return line, reaching the fuel pump to mix with the fuel, and passing on to the injector as fuel. This loss ran as high as several gallons in a very few hundred miles.

Drivers, not satisfied with engine output as set by the manufacturer and maintenance man, forced a change in fuel-pump design. They were convinced that, unless a cloud of smoke poured out of the exhaust stack, the engine was not delivering full power.

The first thing they did after leaving town was to pull up to the side of the road, open the throttle setting, and boost fuel consumption from a 32 to 34-cc setting to as high as 45. This sent engines back to the shop within a few thousand miles.

After trying a number of unsuccessful changes, the engineers went to the pump insides and devised a positive throttle stop that could not be changed without removing the pump from the engine. This finally eliminated all road adjustments and raised mileage between ring jobs from as low as 5000 to a maximum of over 100,000 and an average of 75,000. It upped major overhaul from 75,000 to about 200,000 miles.

Just how much mileage is attainable with ideal operation will remain a matter of conjecture because of the too-variable human element. But the conscientious driver working with the maintenance man can be invaluable in lengthening engine life and bettering performance. (Paper "Diesel Engines and Their Fuel Systems," was presented at SAE Spokane Group, Jan. 10, 1947.)

Practical Engineering Marks Tucker Torpedo

Digest of paper

By KENNETH E. LYMAN

The Tucker Corp.

COMBINING for the first time recent but accepted engineering advancements that stress safety and reliability will make the coming Tucker car a superior product, says Lyman. Outstanding features he describes, are:

• The opposed engine. It takes up less room vertically – important for a rear-engine installation. It will give smoother performance because the crankshaft is short and rugged. Years of experimentation and the war proved the practicability of fuel injection.

• Hydraulic valve actuators. They will give smoother, more reliable, and longer trouble-free performance for less mechanism than present cam-shaft and push-rod installations.

• Sealed cooling system. One such system ran more than 80,000 miles with a loss of less than one pint of coolant.

• Disk brakes. Proved during the war, these brakes may be more expensive; but they will be cheaper to service and safer.

• Improved front-wheel mounting. The front wheels turn on a vertical axis through the centerline of the tires. This facilitates steering and betters control over rough roads and during tire failure.

• Driving safety. A rubber-lined crash compartment in the front and windshield glass channels will release glass on sharp impact from inside. The lighting system will be built so that the center light turns with the wheels. Each of the three headlights has a separate fuse to prevent blackout in case of a short.

• Safer electrical system. The maze

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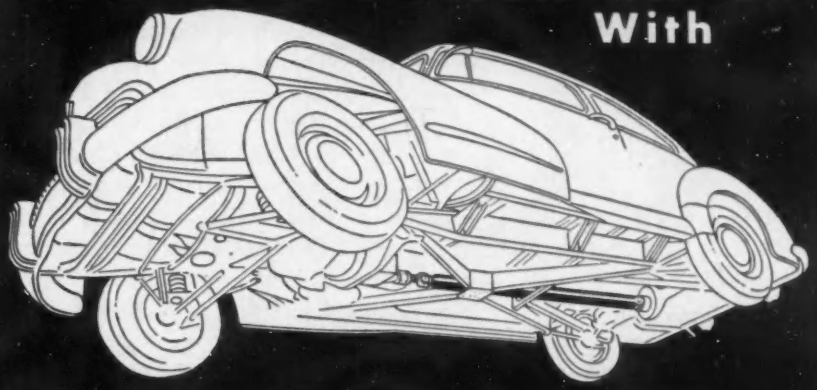

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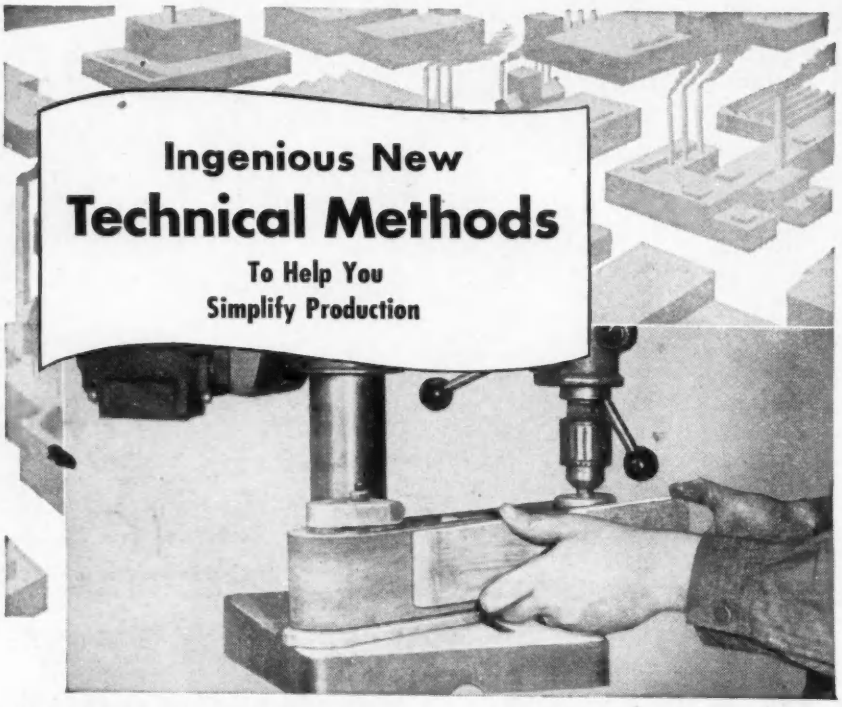

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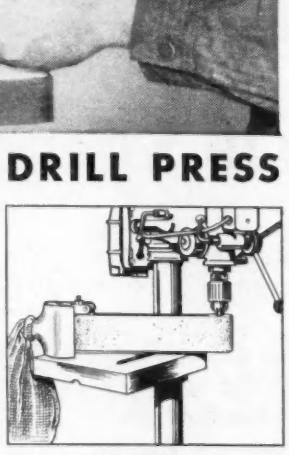

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A *Timely* MESSAGE FOR DESIGN ENGINEERS . . .

SOME AUTOMOTIVE APPLICATIONS OF S.S.WHITE SHAFTS

REMOTE CONTROL
Choke Valves
Clock Setting
Drain Valves
Engine Governors
Mileage Reset
Radios
Radio Antennae
Spotlights
Heaters

POWER DRIVE
Movable Tops
Speedometers
Taximeters
Truck Recorders
Windshield Wipers

The "housing" problem presented by this automobile clock was — to put the clock where the panel designer wanted it and, at the same time, have the hand-setting knob in a convenient spot.

From a glance at the picture you can appreciate how completely the S.S.White flexible shaft combination solves this problem. Obtainable in any required length, it gives complete freedom in placing both the clock and the knob.

A similar arrangement is used for resetting trip mileage on the speedometer. Other automotive applications of S.S.White shafts are listed at the left.

The message for design engineers in these applications is this — S.S.White power drive and remote control flexible shafts completely eliminate the "housing" problem for accessories which require driving or regulation. They come in a wide selection of torque capacities which will reliably deliver power or provide smooth, sensitive control between any two points in a car, bus, truck or other motor vehicle.

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of wires and soldered connections in present-day cars will be replaced by multiple cables and multiple snap-on connectors to guard against electrical failures and fires. They were used in wartime airplanes.

Giving free rein to vision, subject to rigid test, achieved success for automotive pioneers in the past despite strong skepticism. The Tucker car is no exception to the rule. (Paper "The New Tucker Car" was presented at SAE New England Section, Boston, April 8, 1947.)

Joint Passenger-Cargo Airline Service Urged

Based on a paper

By CHARLES P. GRADDICK

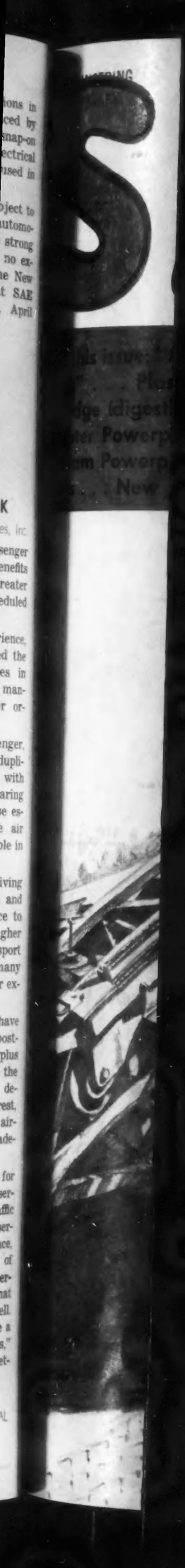
United Air Lines, Inc.

MAINTAINING combined passenger and freight air transport benefits the most people by offering greater safety and economy than nonscheduled operators.

Through long years of experience, certificated carriers have attained the aviation know-how and facilities in maintenance, communications, management, traffic control, weather organization, and engineering.

Establishing separate passenger, freight, and mail airlines would duplicate such facilities and services, with all users of air transportation bearing the extra cost. And most of these essentials to safe and progressive air transportation are just not available in nonscheduled operation.

Exclusive freight airlines depriving scheduled operators of their mail and freight traffic offer no new service to the public. And it can lead to higher rates, weakening of the air transport system, and either bankruptcy of many scheduled and nonscheduled lines or excessive government subsidies.

True, nonscheduled operators have done a good job in the immediate postwar years with bargain-price surplus DC-3's and DC-4's – developed by the airlines. But established carriers, despite accusations of lack of interest, were heavily committed for new airplanes to provide the public with adequate service.

Currently the airlines are aiming for the same high standards of speed, service, and efficiency for cargo traffic that has characterized passenger service. Established airlines' experience, facilities, and growing knowledge of all-weather flying offer freight operation advantages far exceeding what the non-scheduled operator has to sell. (Paper "Should Freight and Mail be a Separate Operation from Passengers," was presented at SAE Summer Meeting, French Lick, June 5, 1947.)